THE SCIENCE TEACHER

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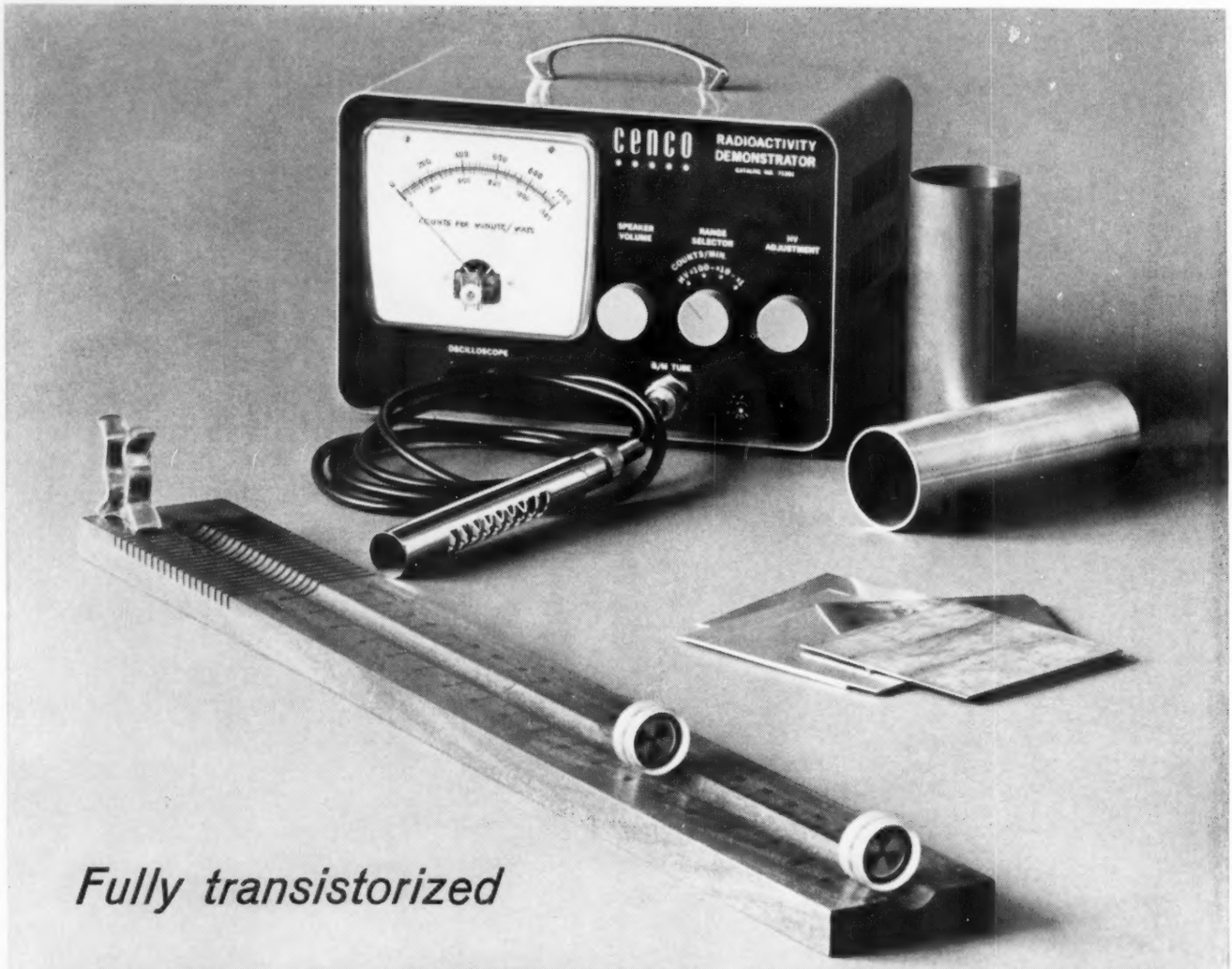

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Contains 439 basic facts on: Measurements, Laws, Rules, Theories, Motion, Work, Power, Machines, Electricity, Magnetism, Electronics, Radio, Weather, The Atom, Nuclear Energy, Refraction, Color, Reflection, Illumination, Matter and Force, Force, Heat, Change of State, Wave Motion and Sound, Sound and Music, Appendix, Famous Physicists.

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Contains 352 basic facts as follows: 104 Definitions, 78 Postulates, 170 Theorems.

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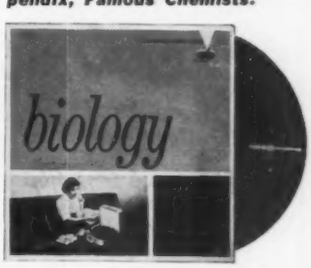
Contains 475 basic facts on: Symbols and Valences, Water and Solutions, Colloids, Halogens, Laws and Measures, Metals, Laboratory Preparation, Commercial Preparation, Common Names for Chemicals, State and Change of State, The Atom, Appendix, Famous Chemists.



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The National Science Teachers Association is a department of the National Education Association and an affiliate of the American Association for the Advancement of Science. Established in 1895 as the NEA Department of Science Instruction and later expanded as the American Council of Science Teachers, it merged with the American Science Teachers Association and reorganized in 1944 to form the present Association.

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Another milestone in Association achievements has been reached—the publication of the first title in NSTA's Vistas of Science series. *Spacecraft* is new, up to date, authentic, and, perhaps most important, it is geared to the learning and teaching situation in the classroom. All of us—authors, publisher, sponsor, staff—are anxious to have your reactions based on the test of actual use.

Is our pattern of content satisfactory, consisting of some background in the area, a portrayal of how scientists go about their work, what some of the current problems are, and suggestions for student activities?

Do students find the book interesting, informative, readable, motivational? Does it help them locate and define projects for further study?

It may help to place the Vistas in perspective. This series of books (14 more titles are "in the mill") is an important element in NSTA's total Future Scientists of America program. The principal goal of FSA is to help teachers guide students in experiences that are representative of those of practicing scientists. The central activity in the scientific endeavor is *finding out* through various modes of inquiry such as experimenting, collecting data from observations, reading, etc. Reporting via written and spoken words is also an important phase of scientific activity. The FSA program might be thought of as circular in character with possibilities for students to break into the circle and keep going.

Suppose, for example, that a particular student wants to do a science project. He might get help from a Vistas book, or the two FSA publications—*If You Want To Do a Science Project* and *Encouraging Future Scientists*, or the soon-to-be published *Project Ideas for Future Scientists*.

A student carries out the project, including the preparation of a written report. This report should be entered in the Future Scientists of America Awards contest. On the basis of regional judging, over 600 FSA recognition medallions plus school certificates are bestowed to students in grades 7-12. Also, all eleventh- and twelfth-grade winners are automatically entered in final, national judging for the selection of 25 recipients of FSA college assistance scholarships of $250 each.

In general, the doing and *reporting* of projects are carried on as activities of school chapters of the Future Scientists of America. Currently, nearly 1000 chapters and 30,000 students are enrolled in this program of FSA. Verbal reporting and discussion of projects goes on in many of the chapters and through other outlets. FSA-sponsored congresses or seminars for science students will be developed during this year.

Reports of FSA student projects may be published in the "Tomorrow's Scientists" section of *Science World*. Also, these reports, some 6000 of which come to NSTA each year, are extremely useful in developing the activities section of the Vistas and in the preparation of FSA publications. Thus the feedback that closes the circle.

NSTA recognizes that the key factor in making this plan work is the classroom teacher. Our purpose is to help make the teacher's task easier and more effective, certainly not to add increased burdens. Evaluation of our efforts and services by those best qualified to judge—teachers and students—is earnestly sought.

Robert H. Carleton

P.S. Be sure to check pages 39-46 for ADVANCE CONVENTION DATA.

Academic Year Institutes

The National Science Foundation (NSF) has announced support for fifty-five Academic Year Institutes for 1962-63, nearly all of them for high school science and mathematics teachers. Approximately 1500 teachers will be awarded stipends plus certain allowances for dependents, travel, tuition, fees, and books. A few AYI programs have been designed for special groups such as physics teachers, teachers of advanced placement courses, etc. Since time is short for making application—the deadline is January 20, 1962:

1. Obtain brochures, information, and application forms from the AYI Director *at the host institution* of your choice.

2. Write to NSF, Washington 25, D. C., if you wish to have a list of all the institutes and their directors.

3. Act now if you wish to apply for AYI in 1962-63.

Annual Joint Meeting of NSTA with other Science Teaching Societies . . . At the 128th Meeting of the American Association for the Advancement of Science December 26-30, 1961, Denver, Colorado . . . See October and November TST.

THE SCIENCE TEACHER

Volume 28, No. 8 — December 1961

The Journal of the National Science Teachers Association, published by the Association monthly except January, June, July, and August. Editorial and executive offices, 1201 Sixteenth Street, N.W., Washington 6, D. C. Of the membership dues (see listing below) $3 is for the Journal subscription. Single copies, $1.

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* Includes the *Elementary School Science Bulletin* published monthly from September through April of each year.

My check for membership dues for this year is to me the best investment possible for the price to further science teaching progress.

In October, I met with a group of intermediate and junior high school teachers from all parts of our state. My talk and demonstrations included points on how to develop an investigative approach to science at an early level, rather than to develop a textbook approach to learning by isolated rote statements. Your reference materials were received, as well as the literature about NSTA.

I want to express my thanks to the Association for the great job it is doing to help science teachers.

CHARLES H. SCHROEDER
3309 Virginia Way
Longview, Washington

Research Participation

The announcement of no Future Scientists of America Foundation grants for on-the-job research came as a shock. We regret that such a magnificent cause under which research grants were provided for high school teachers, must die for lack of support. Is it possible that there might be some hope of revival if those of us who were recipients of funds made reports and evaluations of results available for public knowledge?

Perhaps some of the problem lies in the fact that such work in the high school is slow going because of the crowded high school day. We plan to write you a report of our progress. It is difficult to assay the many benefits which have come our way because of the grant. In spite of this termination decision, however, we expect to continue in the similar lines of investigation which we started.

Surely giving similar opportunities to other schools is worthy of support. Is there no way to make this clear to potential donors?

RUTH O. WENNER
Lyons Township High School
Western Springs, Illinois

I was quite shocked to hear that the FSAF grants to teachers for on-the-job research has been discontinued. It certainly was a fine program and the students who have worked with me in the past on the blood research program, in addition to those who will help me this year, are deeply indebted to the FSAF for the $350 research grant.

This grant made possible the purchase of equipment and supplies necessary to carry out the research work. The remaining funds, after certain expenditures had been made, were used to take the four students who worked on the project on a trip to Madison, Wisconsin, to visit the University of Wisconsin during the Easter recess in the spring of 1960. Needless to say, the students were tremendously enthusiastic and impressed with their visits to the many laboratories and talks with the outstanding researchers at the University.

In spite of the curtailment of funds, I plan to continue this work with high school students during the academic year. The equipment which we purchased with the grant money will make this possible.

CHARLES W. ANDERSON
Central High School
Norwood, Minnesota

Books Wanted for Asian Students

The Asia Foundation announces an extension of its six-year program to provide books for Asian students. University, college, and secondary level books and journals published after 1945 in all subject areas are requested. Works by standard authors before 1945, however, will be accepted. All books should be in usable good condition. To date about two million books and some five hundred thousand journals have been shipped from American publishers and college student groups to universities in eighteen Asian countries.

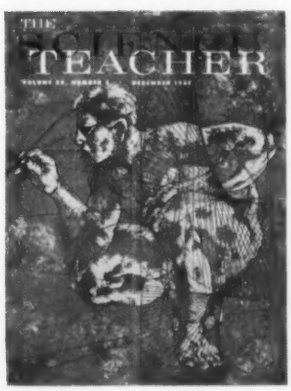
The Foundation will pay transportation costs of the books from the donor to San Francisco for shipment to Asian countries. Additional details may be obtained by writing to *Books for Asian Students, 21 Drumm Street, San Francisco 11, California.*

The purpose of the Asia Foundation is to strengthen Asian educational, cultural, and civic activities with private American assistance. It is a nonprofit, nonpolitical organization founded by private American citizens in 1951 and incorporated in the State of California. Through its resident representatives in Asia, the Foundation makes private American support available to individuals and groups in Asia who are working for the maintenance of peace and independence, and for greater personal liberty and social progress. Projects assisted by the Foundation in Asia are developed and administered by Asians, and most of the Foundation's assistance is designed to help programs get started and induce local support.

The activities of this group may take many forms, depending on local needs and resources: grants or loans; travel funds; advisory personnel; supplies or equipment; books; or other material contributions. Cooperation with other foreign and international assistance programs are included, if no other sources are provided. Projects may be in many fields including education, research, community development, social welfare, cultural activities, international conferences, and related programs which may contribute to social progress and to the exchange of ideas and experiences.

Funds for the work of the Foundation are obtained from voluntary contributions such as charitable trusts, philanthropic organizations, individuals, and corporations. For additional information or a report on all activities, write to 550 Kearny Street, San Francisco 8, California.

NSTA strongly recommends that schools and school systems, whenever possible, cooperate to assist the Foundation in this endeavor to obtain books.



THIS MONTH'S COVER . . .

In the remarkable combination of living nature and purely geometrical constructions, artist and scientist alike gain by the work of Hans Erni, the contemporary painter, artist, and author, from Lucerne, Switzerland.

Other works of Hans Erni are illustrated in his book "Elements of Future Painting," edited by Frank C. Thiessing, 1948, and published by Zollikofer and Company, St. Gall, Zurich, Switzerland.

The cover entitled "The Architect" is an original by Erni and was selected for its vitality in portraying the subject theme "creativity" of the lead article by Calvin W. Taylor on page 6.

Season's Greetings
from NSTA Staff

FINDING THE

By CALVIN W. TAYLOR

Professor of Psychology, University of Utah, Salt Lake City, Utah

EFFECTIVENESS in science and effectiveness in science education are of considerable importance, and both contain areas that involve research studies. This means that the scientific method should have application in improving our effectiveness in attempts to solve the problems that persist in our current everyday teaching situations. One of the major problems facing science education is speeding up the application in education of research findings that have relevance.

Currently, a number of research projects are under way which have pertinent applications to science education. To date, we are exploring some areas in which we hope to bring to light specific examples of these. In particular, a report written by six researchers to be published this year summarizes the research knowledge and research needs in creativity, the specific area in which we will confine these remarks. The report is a compilation and extension of three national research conferences held in 1955, 1957, and 1959 (see reference 7), supported by the National Science Foundation on the identification of creative scientific talent. The first three conferences have been published, and the 1961 report should be completed by the end of the year and ready for distribution.

Six main points might be explored in this subject area:

1. Are There Losses in Creative Talent along the Academic Ladder? It is of great potential value to the nation to obtain further insights into this question in order that (a) losses of the most relevant types of manpower needed in research work in scientific laboratories and in other high level activities can be reduced, (b) the most relevant types of talent will be developed in our educational programs, and (c) such talent will be most fully utilized to speed up scientific and related progress in the nation.

This point should be carefully considered because there *may be* an above average drop out of those with creative talent through the academic program. Since early evidence suggests that fellow students and teachers may *not* favor, in fact may even disfavor, more creative students; and likewise, principals and supervisors may *not* favor more creative teachers, we should determine what the creative talent losses are at each crucial level through the present school system.

Another related loss to consider is a decrease of creative talent within individuals as they move along the academic ladder. If this is true, as many are suspecting, we should again be deeply troubled about such losses.

2. There Are Multiple Types of Contributions in Science with a Different

---

NOTE: Condensed by the author for TST from an address entitled "What Kinds of Learning and Thinking Do You Want in a Science Student," delivered at the NSTA Rocky Mountain Regional Conference held in Salt Lake City, Utah, August 25-26, 1961.

Set of Psychological Characteristics Needed for Each Type of Contribution. This is a major finding in one of the research efforts which we have just completed for the Air Force (8).* We found great complexity both in the number of contributions and in the variety of characteristics needed for each type of contribution. We conclude that no single-variable panacea will serve and account for much by itself in this area. In other words, we found many variables that were working, with each one being of some importance.

3. Are There Multiple Types of Creativity and to What Degree Do These Types Cut across Disciplines? This is a major issue in creativity that needs to be resolved through the use of suitable scientific techniques available for such determinations.

4. Are There Educational Organizational Problems in Encouraging and Developing Creative Scientific Talent? Briefly summarized are a few of the relevant research findings. Torrance (9) reported at the 1959 Utah conference that fellow students may exert group pressures on students with creative characteristics. Group pressures can include a developing of *sanctions against* the person and an over-organizing and building of other controls into their world. Getzels and Jackson (3) also reported that creative students favored somewhat opposite characteristics for themselves than they felt that teachers generally wanted in students. Thus, students with creative characteristics may tend to be among the less favored in school situations.

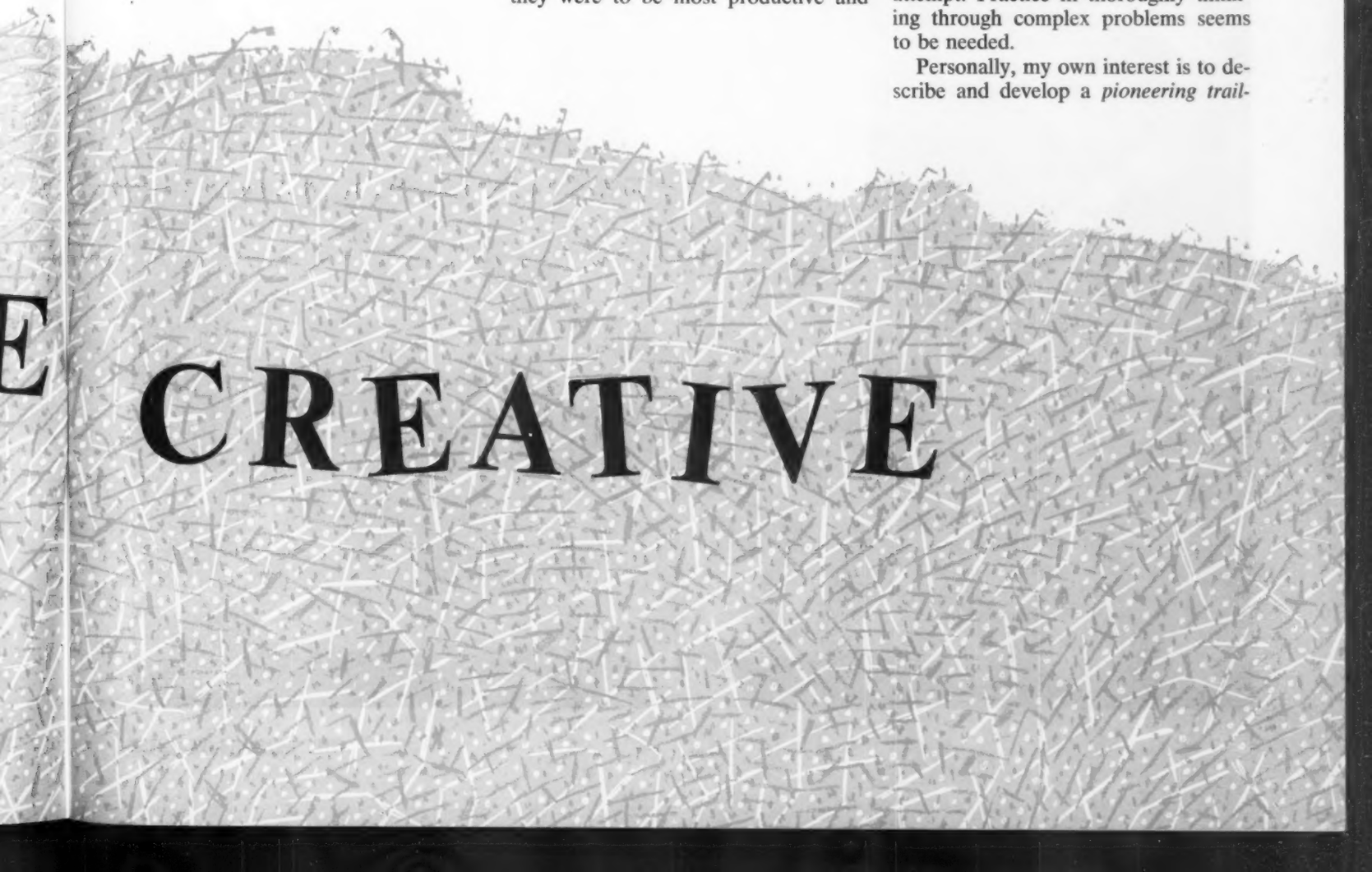
Some indirect evidence that key people in school systems are not necessarily seeking for or encouraging creativity is found in the report by Jex (4). High school science teachers with creative characteristics were rated below average on their over-all teaching ability, so that they apparently tend to be looked upon with some disfavor in certain educational settings. A study is needed to determine whether those teachers develop creativity traits in their students more than other teachers do.

In our study of the working conditions of scientists at two research centers, we received many suggestions from the scientists about factors that hindered their working at top efficiency which they felt should be changed if they were to be most productive and creative. It was found according to job descriptions that the highest salaried scientists were responsible for 13 or 14 activities whereas the beginning and the lowest paid scientists were responsible for only 3 or 4 activities. Thus, the inexperienced and the lowest salaried scientists were most free to concentrate and sustain their efforts on a small number of activities, whereas the highly paid scientists were spread so thin that one would generally not expect them to produce anything very profound or creative. An over-all impression was that scientific work had merely been plugged into an existing organizational structure without even a second thought as to whether that type of organization was suitable, let alone being ideal for creative scientific work. One wonders if the same organizational question exists in science education.

Two eminent scientists, William Shockley and Edwin Land (1), have independently stated that it has taken them long hours of sustained, uninterrupted work to break through their most difficult problems. As Shockley indicated, most people have not learned (*nor have they been taught*) to devote and sustain the long effort often required, so they quit prematurely in their attempt. Practice in thoroughly thinking through complex problems seems to be needed.

Personally, my own interest is to describe and develop a *pioneering trail-*

* See references.



blazing type of creativity. This type would involve thinking outside of the present framework, moving ahead and blazing trails which ultimately open the way for others to follow. In one sense this is *creative leadership,* being in the vanguard of history, though at times this leader may not have many followers until a generation or two later. For example, I am told it was Cézanne—*and not the academicians who fought him* (he was leading an advance away from them)—who was the main line of development of French painting. So academicians can fight progress around themselves.

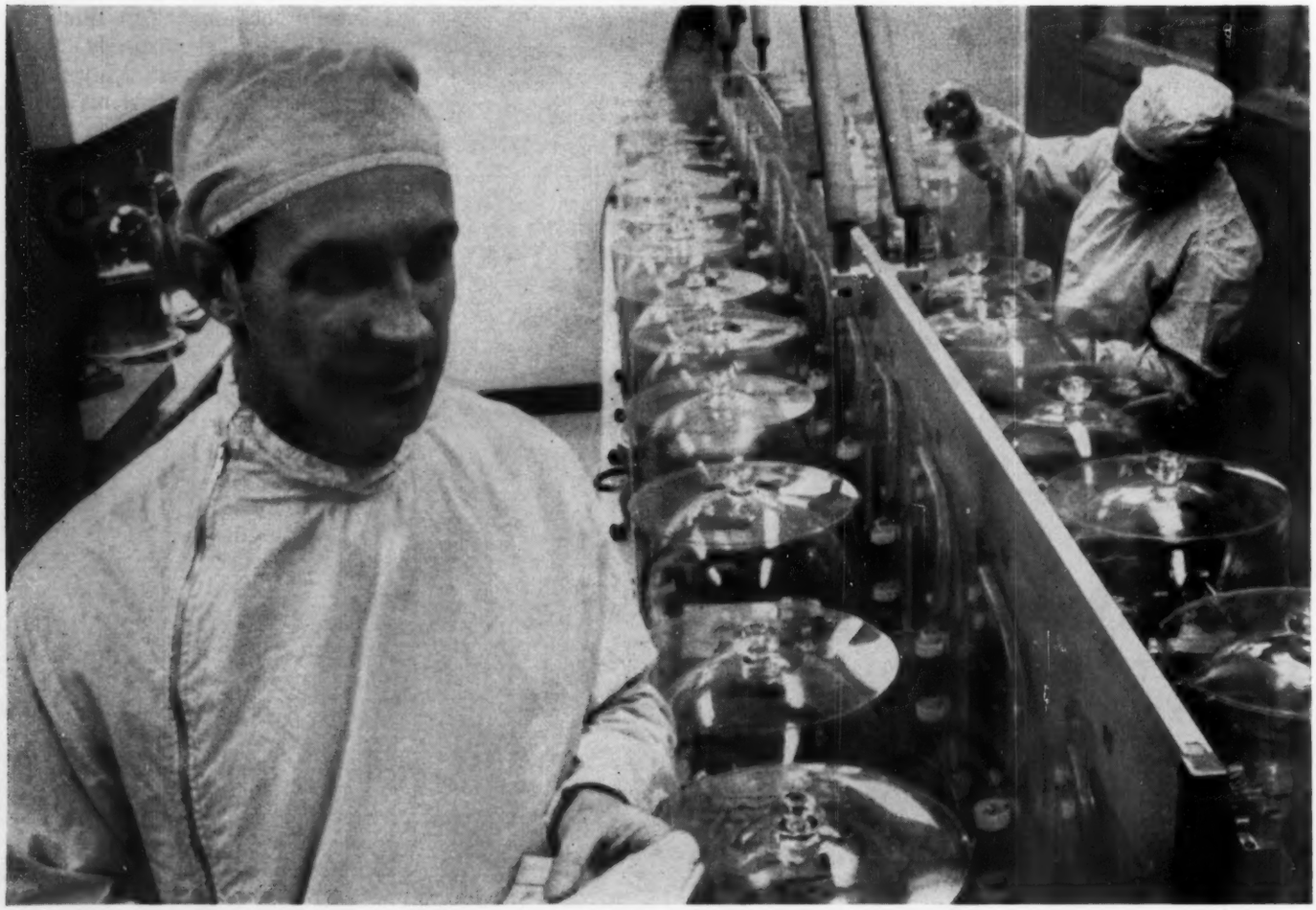
I suspect that creative persons may try to work their way out of "needless restrictions" built into organizations by others which may limit the effectiveness of an organization. One of our conference participants said that "anyone really worth his salt" would not let such needless restrictions stop him from doing his best work possible. At another time in the conference series the same participant reflected that the majority of those persons who had truly reshaped the world had finally done their work on their own, outside of existing organizations.

George Washington, the first President of our nation, recognized a major problem in trying to make improvements in organizations. He said that reforms in an organization are difficult because they must come about through persons who have been most successful within the old system, *no matter how faulty the old system is.* One wonders whether education will be as resistant to change—for example, as resistant to the use of scientific research—as many parts of the military were two decades ago.

5. Is Education of Science Students a Problem Area with Many Changes Needed? Both what the texts say and what is taught about the nature of science is apparently lacking. These descriptions seem to emphasize the verification stages of science almost exclusively; practically no room or little attention is given to the creative stages and to other trail-blazing activities—which are the real crux of the scientific method of producing new science and of pushing ahead the frontiers of knowledge.

Recently, it came to me as a surprise to hear a bright undergraduate student in science tell majors in the arts how science differed from their fields. He said that "there is no place for *intuition* in science." And yet "intuition" was one of the most valid characteristics in the Air Force study out of the 130 characteristics evaluated, being related to about half of the types of contributions of scientists. On this point James Stephens recently said: "I have learned that the head does not hear anything until the heart has listened, and that what the heart knows today, the head will understand tomorrow." It should

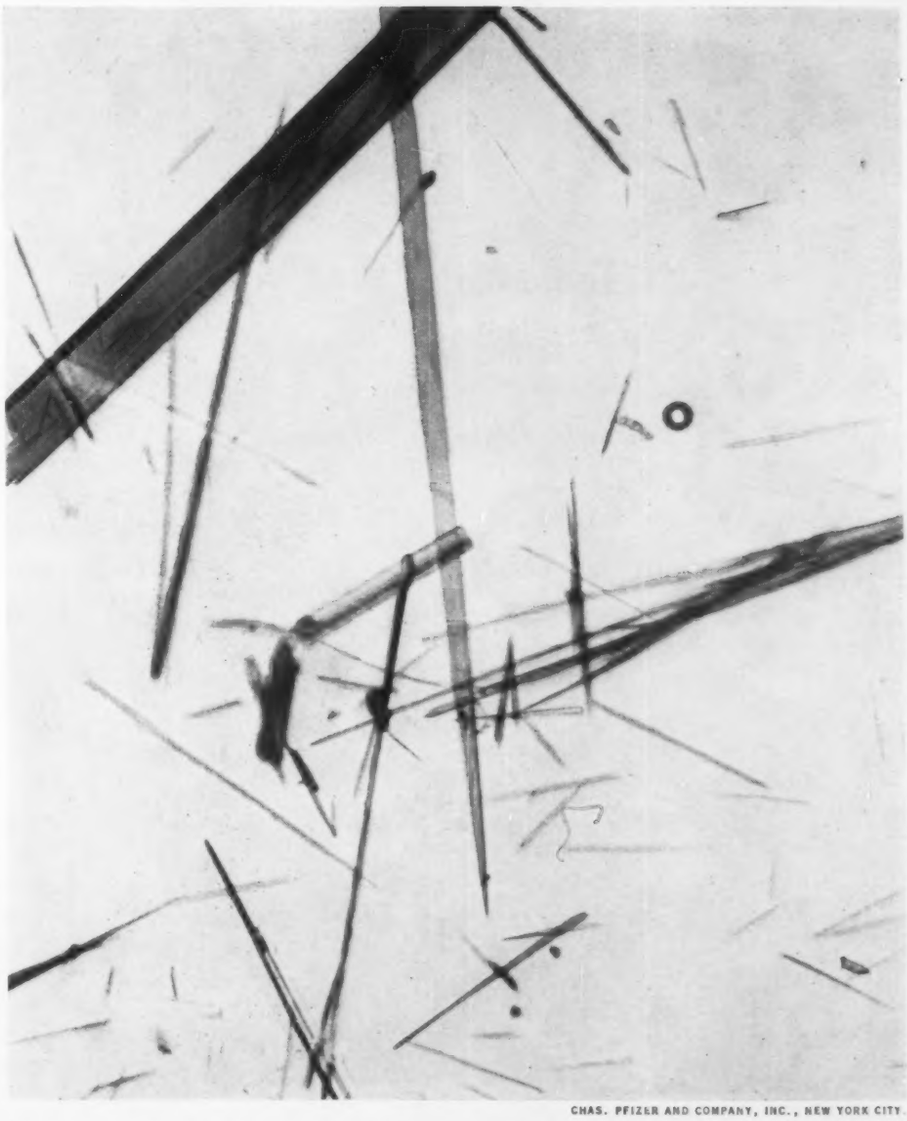
A dust-free assembly line under glass is a part of research facilities planned to free the scientist for more productive and creative activities. Gyros subjected to high vacuum and set in motion are tested in the large laboratory bell jars at the facilities of the Sperry Gyroscope Company in Great Neck, New York.



be added that a creativity score was valid for more types of contributions (12 out of 17) than any other score in our Air Force study.

More than once, my view has been given that science has more to learn from the arts than vice-versa. I was told that the typical method of teaching science, namely of having students learn a large body of subject matter and of techniques before doing new work on their own, was practiced once in art and was called the *academic approach to art*. One person said that they gave this up rapidly in art as not being sound. Another person said that they would never dream of using such an approach in art or related studies.

Art education may be more valuable in this age of science than is generally realized. By the approach of teaching creativity through art, as stated by Lowenfeld, perhaps a better understanding of the nature and importance of creativity can be transmitted to more of our students. Since there has been so little emphasis on creativity in students in most of science education, should we send science students to art education to get at least some creativity training in their background, even though it may not all transfer to the sciences or to the other fields of human endeavor? At least, maybe we should send science students to art for creativity until science teachers learn how to bring creativity in valid effective ways into science education.



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Structures revealed in clinical studies of new drugs suggest an orderliness and organization which characterizes the creative mind. The crystals, seen through a microscope, show the fine structure of a new drug to be used in the treatment of mental disorders after completed clinical trials.

Evidence suggests that quite different thinking processes are involved when we learn existing knowledge and systems than when we produce new ideas, new knowledge, and new systems. Many of our present academic programs in science may be stressing memorization and other noncreative activities so that the work habits which are being developed are strongly ingrained and are valuable in reciting and accomplishing noncreative things. Some of the successful persons may show real resistance and perhaps emotional disturbances if relatively late in their education, or any time afterwards on the job, they are asked to be creative. Such conflicts might be avoided if creativity training and encouragement had occurred much earlier or even throughout their entire academic training.

One suggested approach in creativity training is to remove hindrances to creativity and to untrain noncreative habits. Science teachers who have tried to remove such hindrances or more directly to help students learn to generate and express ideas of their own, also have found excitement and even new ideas for themselves in the process.

Perhaps one reason why our society does not give much moral and tangible support to education is that persons leave the academic world and find, to some degree at least, that intellectual, *i.e.,* learning and thinking characteristics in which they are highly trained are not called for in the world of work as much as they expected. Contrarily, other intellectual characteristics in which they have had little training may be crucial characteristics in their part of the world of work. Admittedly, education has a responsibility, at least equally important and probably more challenging, to have students exercise and develop all of the known thinking abilities as their minds feed upon, toy with, and otherwise process and utilize current knowledge.

6. What Can the Progress in Identifying Creative Characteristics Mean to Science Teachers? Before concerning ourselves directly with creative characteristics, preliminary comments will be made about certain widely available measures of psychological characteristics. If school grades were highly valid measures of creativity, no extensive problem would exist in identifying those with more potential to be creative from

NATIONAL HIGH SCHOOL PHOTOGRAPHIC AWARDS

Creative characteristics may be discovered in a child's early experience with unusual phenomena as he persists for answers through curiosity and experimentation.

those with less potential. Although certain school grades have been shown to have a little validity in predicting creative performance, school grades in general are not very valid predictors of creativity. The nature of school activities may have to change for at least a portion of the total school periods to increase the chances that performances and behaviors, related very highly to creativity, would be exhibited and later scored and incorporated into academic grades earned in the classroom.

A somewhat similar argument is that if IQ scores from traditional intelligence tests were highly valid measures of creative characteristics, again there would be no particular problem. But the strong suspicion is, with support from many factor studies and from the Getzels-Jackson (1959) finding which has been replicated several times by Torrance (1959), that IQ scores are not highly valid measures of creative characteristics, with a large portion of the total components of creative performance being essentially unrelated to IQ scores in any possible way.

In research on identifying creative scientific talent, a broad approach has been emphasized, somewhat in contrast to the identification of IQ type of talent by means of a single score. Only a few samples of creative characteristics will be mentioned. To what degree do science teachers presently tolerate or even positively encourage those with the following intellectual, motivational, and personality characteristics?

From the research results of his own and of many other workers, Guilford has evolved and listed the following intellectual characteristics as most likely to be valid measures of creative talent: originality, redefinition, adaptive flexi-

bility, spontaneous flexibility, fluency of associations, fluency of expressions, fluency of ideas, fluency of words, elaboration, and probably some evaluation factors might even be included.

In the Air Force study, Ghiselin (Taylor, *et al.,* 1961) developed a Creative Process Check List in an attempt to identify persons whose problem-solving processes resemble those traditionally reported to be present in creative work. Our verbal revision test is at least analogous to the manipulation, restructuring, and reworking of ideas found both in the earlier and later stages of the creative process. It is probably also related to the ability and tendency to strive for more comprehensive answers or solutions or products, another feature found in studies of creativity. Unfortunately, too few occasions in our academic programs require such strivings for higher quality or for more original and workable products. And what do science teachers do when a student strives for a better answer than either the text or the teacher has given him?

In the same project, Ghiselin also suggested that we try take-home aptitude tests to find those who continue to be involved and who jot down additional responses whenever and wherever they occur.

Quality Ratings

A study of the products of scientists led to the finding of two quite unrelated quality ratings. One was called high level *quality without originality* and the second was *originality type of quality*. Schools may increase their chances of having the originality quality emerge if they will call off the requirement for the other type of quality in selected assignments. Probably more adequate training is already being given for quality without originality.

Another relevant characteristic may be an ability to make good intuitive decisions on the basis of incomplete information.

Response-set factors may measure characteristics functioning in creativity. For example, we have found one called "broadly diffused attention." This type of attention has often been a part of the description of the crucial moments preceding the insight stage of the creative process. Another one called "resistance to idea reduction" may be related to the ability to make some second order refinements on broad generalizations, whereas those not so resistant to idea reduction may be related to the ability to make the first order, broad generalization.

Some motivational characteristics suggested are the great dedication to work, intellectual persistence, liking to think, liking to manipulate and toy with ideas, need for recognition for achievement, need for variety, need for autonomy, preference for complex order and for challenges therein, tolerance of ambiguity, resistance to closing up and crystallizing things prematurely coupled with a strong need for ultimate closure, need for mastery of a problem, insatiability for intellectual ordering, and a need to improve upon currently accepted systems. High energy with vast output through disciplined work habits is usually found to be apparent.

We need to know better how to get students more deeply involved in their work, for Bloom (2) has indicated that science students who truly become involved in research work and in the research role during graduate training, tend to become the productive researchers afterwards. The reverse may be even more generally true.

From personality evidence to date, creative persons are more devoted to autonomy, more self-sufficient, more independent in judgment (contrary to group agreement, if needed, to be accurate), more open to the irrational in themselves, more stable, low in sociability, more interested in unconventional careers, more feminine in interests and characteristics (especially in awareness of one's impulses), more dominant and self-assertive, more complex as a person, more self-accepting, more resourceful and adventurous, more radical (Bohemian), more controlling of their own behavior by self-concept, and possibly more emotionally sensitive, and introverted, but bold.

Other potentially important over-all features suggested are that the creative individual has a disposition to produce adaptive responses which are original in nature. A more extreme and perhaps oversimplified suggestion pertaining to adjustment is that while many individuals focus on *adjusting to their environment,* at least some creative individuals have their attention on trying to *adjust the environment* to improve it in ways that they sense and feel are urgently needed.

Let me add that anything that can be done to modify our educational programs and our environmental conditions to increase the emergence of creative activity will simplify and reduce the burden of identifying the more creative individual. This last suggestion cannot be overstressed.

Other Challenges for Science Teachers

As educators, let us show the creative characteristic of being able to toy with the potentialities instead of merely focusing upon the actualities of the present situation. A professional writer recently commented that the higher the concept that a person has of the potentialities of students, the more impatient he will be for improvements in education that become necessary.

We need to learn, through research, more about how some science teachers light a spark for science in their students that seems to be almost unextinguishable thereafter. What have these teachers done that could be taught to others so they, too, could learn to light such strong sparks in their students? We need to find out how to put across the message to students that science can be exciting. We also need to know what to do so that the learning of science will be fun.[1]

Why do some potential developments appear to be challenging to some teachers but threatening to others? How can we help more teachers to see the challenges ahead more than the threats? For example, teaching machines when properly used might free us as teachers to do all the other important things that we have never yet had the time to do (and may not yet know how to do). Do we as teachers get on the right side of important new developments or do we follow a path of least resistance and end up by being most resistive? What are science teachers and curriculum people going to do about the hundreds of proposals to NSF of new and important experiences (not yet in the science curriculum) for high school students during the summer months?

What do you think happens in question-raising sessions after a special lecture in summer programs when high school students and high school science teachers are mixed together in the audience? We are told that the students

[1] See the author's comments under "The Creative Child." *Look,* 25:111. November 7, 1961.

This is the year to experiment with programed learning

A Message from TMI-GROLIER to Teachers and School Administrators

Educators and school administrators are generally agreed today that programed learning is certain to be broadly adopted in the nation's schools in the coming years.

The basic questions no longer concern the *merits* of programed learning, but, rather, the best *methods and materials* for introduction in the specific circumstances of each school system.

And this is a matter which each school system must establish for itself. There is much data and experience available, and many types of materials. Not only must these be objectively evaluated under classroom conditions, but educators will want to resolve such questions as: Should programs be used with—or without—machines? . . . Should programs be used by all students in a class? by advanced students only? by the least advanced? . . . What should be done with students who finish a program in less than the normally allotted time? . . . Should teaching machines and programed courses be substituted for conventional methods of instruction? to reinforce them? to supplement them?

By familiarizing themselves now with the theory of programed learning, experimenting with ways of using machines and programs in the classroom, and methods of fitting programed courses into the curriculum, educators will make it possible for subsequent adoption to be accomplished with a minimum of uncertainty and disruption.

TMI-GROLIER Materials Incorporate Findings of School Research

Many of the questions that will naturally occur to educators have already been broadly investigated by TMI-GROLIER programing and field testing facilities. Our materials now incorporate innovations and improvements suggested by both our cooperative research activities with several of the country's leading school systems, and by information derived from the independent experimentation of hundreds of individual schools. For example, we find that regional differences and high rate of change in some of the sciences make it preferable, for the present, to program elements of certain subjects, rather than curriculum years. We believe that multiplication and division, fractions, addition and subtraction, for example, should be programed independently, rather than as second, third, or fourth grade arithmetic. Treated as modular curriculum units, these programs can be easily adapted to a wide range of teaching situations.

In addition to improvements made in the basic programs through school evaluations, TMI-GROLIER will shortly be marketing a new version of its basic MIN-MAX Teaching Machine—the Mark II—which will incorporate design features that schools have told us are essential, e.g., automatic paper feed and re-usable programs. Our programing facilities in Albuquerque, New Mexico, (Teaching Machines, Inc.) operate under the personal supervision of men who are acknowledged leaders and pioneers in the field. TMI-GROLIER's current programs provide a wide range of subjects chosen to indicate the rich possibilities of the new medium. Thirteen basic courses in programed learning have been completed and thoroughly tested.* Eventually TMI-GROLIER programs will include virtually every subject in the elementary and secondary school curricula.

A Challenge — And Opportunity — For The Coming Year

The experiments which schools are now conducting, and will conduct in the coming months, are helping to prepare the way for one of the most important advances in the history of education. Enlightened educators recognize that the process is a lengthy and complex one and that to defer experimentation now may result in undesirable lags later when broad adoption is generally indicated.

TMI-GROLIER is eager to assist in programs of controlled experimentation by schools during the coming year, and to facilitate—in every possible way—the sharing of meaningful classroom experiences.

To that end, we are developing a wide variety of materials. If you would like to be placed on our mailing list to receive them, write to us under your school letterhead. Our educational consultants and field representatives are prepared to offer invaluable advice and assistance. In addition, we are constantly publishing literature on various aspects of programed learning and its implications to teaching and teachers. Write for a list of these publications to Dept. 75.

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are not at all affected, but that the science teachers "clam up" and do not raise any questions. And what do you think of a research participation center's comments that of six different groups joining their research team during the summer, the high school students clearly are their most preferred students, while the high school science teachers seem to profit least of all among the groups participating?

How can we help more teachers to have the ability to know when they do not know and in the true scientific spirit, to admit when they do not know and to maintain their curiosity at a high level by seeking to find out and learning how to find out? How can we help more science teachers to participate in research, to learn how to do research, and to encourage their students to do research? How can we extend the research participation experiences to more high school students and how can we maintain through the school year, the high interest in students seen in some of these summer science programs by many of us?

Real progress has occurred along these lines in NSF research participation programs for high school students conducted, among others, by E. A. Mirand at Roswell Park Memorial Institute, J. R. Jablonski at the University of Pittsburgh, R. F. Riley (5) at Polytechnic Institute of Brooklyn, J. J. Sperry at College of Texas (A and M) and Harry Sobel at the Committee for Advanced Science Training in Los Angeles. Mirand and Jablonski, for example, have had high school science teachers as well as high school students in their summer research participation programs. And Jablonski is pioneering further by deliberately trying to have students and teachers in his locality continue their research in the high school setting throughout the academic year by overcoming present obstacles.

We further challenge science teachers to join in the search for better answers and not be too content with present content in science. We also urge all educators, who teach and preach science and who help to produce scientists, to be users of scientific findings and of science as a major approach for solving educational problems facing the nation.

We are personally convinced of the crucialness of the scientist in science. In fact, we state that there is nothing more basic in science than the scientist. It is the scientist, first and foremost upon whom we depend to push forward the frontiers of science. Even when funds are spent on research facilities, we realize that the scientist is being surrounded with these facilities in an attempt to increase his chances of being fruitful. And lastly, we believe that the scientist whom we hope to produce is so vital to science and to the nation that we are turning the scientific method on the scientist and on his characteristics and working procedures. We invite you to join in this effort and to help put the relevant fruits of all research on scientists into educational practice.

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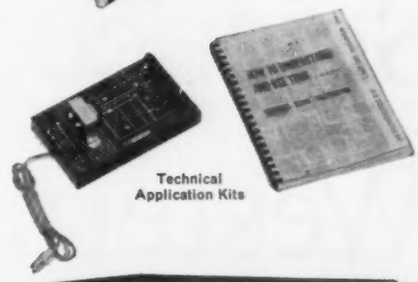

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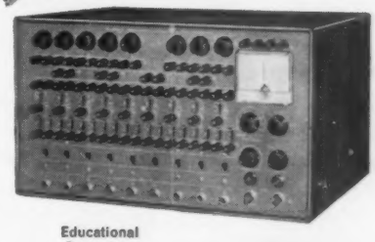

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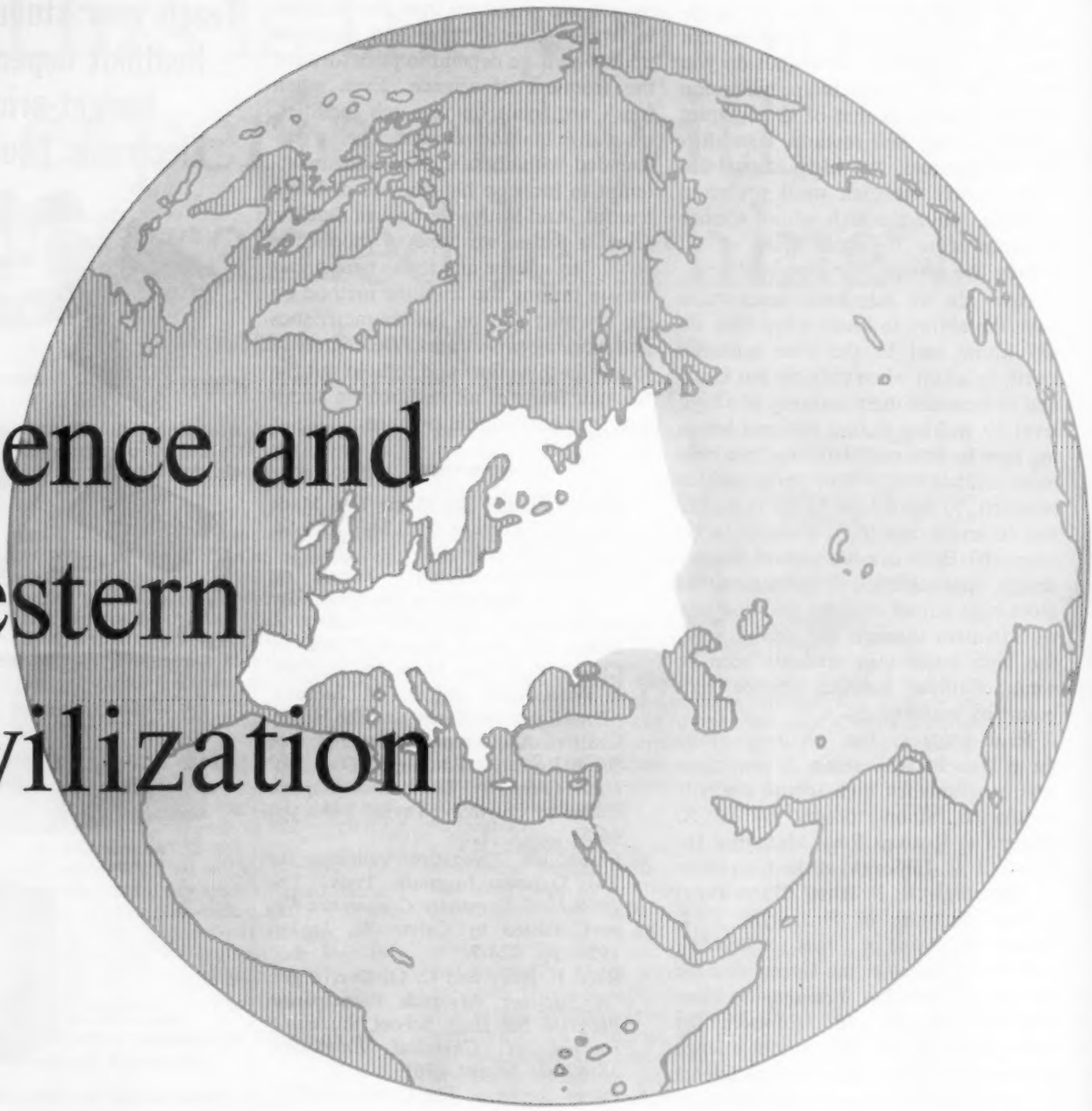
Science and Western Civilization



By ALBERT J. BERNATOWICZ

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WHEN we pause in our teaching to consider our objectives—to decide not only what we want to do but why we want to do it—I suspect we usually stop with rather immediate objectives. On a day-to-day basis we decide on something like, "Cover chapter five," and the "why" is "To get Newton's three laws across." On a slightly more long-range basis we may set ourselves the objective of working through some particularly difficult textbook, and if we ask ourselves "why," the answer is likely to be something as profound as "To give them a real physics course (or a real biology or chemistry course)." This sort of "objective," sometimes amplified with statements about "appreciation of nature," or "awareness of the world we live in" seems adequate when all is going well. But when our teaching seems unsuccessful or unappreciated, when the stack of laboratory reports becomes impossibly high and the summer vacation seems interminably remote, then some of us worry about these objectives. Do they really explain why we keep plugging away? Are they sufficient statements of what we hope we are contributing? Why do we teach Newton's laws? Why teach physics, or biology, or chemistry? Indeed, why teach science at all? What is it about science that justifies it in our curricula from the elementary grades through the college years?

It is not some one objective, of

NOTE: Excerpt from an address entitled "Science and Society," delivered by the author at the NSTA Regional Conference in Hawaii, June 22-24, 1961.

course, which justifies the teaching of science, and no doubt each of us could provide a respectable list, but I will proffer only one for your consideration today. This objective, which is not restricted to science teaching alone, aims to orient the student in western civilization.

Let me try to clarify this statement by reminding you that science is a peculiarly western activity—that the great names and important contributions from the days of Copernicus and Galileo to the twentieth century are associated with Europe and America, and the fairly recent contributions from the Orient seem to be traceable to western influences imposed upon the old civilizations in Asia. With this in mind it is not difficult to see that literature, history, and the social studies are not the only subjects which can give our students both insight and orientation with respect to the milieu in which they are developing; an education in science is equally essential.

Understanding science can modify the cultural (in the sense of *Kultur*) background in two ways. First, it can provide the logical-empirical attitude which is so characteristic of western thought and western systems of values. In some measure we work toward this end when we try to inculcate "scientific method." Second, the student can be made to understand that science does not operate in a social vacuum—there is a reciprocating influence between science and the other segments of society. I had earlier covered this item by suggesting how technology and science influence each other, and how government is influencing science in the space race, but there is a deeper interrelationship between science and society more fundamental than all the others as a *raison d'etre* for science in the curriculum.

The pre-eminent contribution of science to our society has been its influence on western thought. Generally, the impact has affected the intellectual leaders first, and then, transferred to nonscience areas and blended with other ideas, it affects all of us, conditioning our general outlook in a subtle but pervasive manner. The conditioning is so subtle and pervasive that we may unwittingly entertain conflicting outlooks for different situations, as I shall mention in connection with Ptolemy and Copernicus, but this merely emphasizes the extent to which the ideas of great scientists have influenced our thinking through the centuries.

Probably the outstanding contributors in this regard were Copernicus, Newton, and Darwin. Planck, Einstein, and Heisenberg will probably join their ranks when we get more historical perspective, for most assuredly they have already influenced other intellectual leaders and it remains only to see in what guises their ideas reach future generations. There are many lesser figures but I cannot list them all, though their influence is surprisingly widespread. One has only to reflect on the possible connections between the germ theory of disease and such problems as a fly in the soup, the number of bathtubs per capita, the too-common prejudice against "dirty foreigners" and "unwashed natives," or the morale of soldiers without laundry facilities—problems which seem to be emotional, esthetic, military, and even political—to appreciate the extent of this influence from the minor figures. But let us look more closely at the three giants.

Copernicus, Newton, and Darwin

What, to be specific, was Copernicus' contribution? We teach our students that Copernicus developed a theory of a solar system with the sun at its center and planets revolving around the sun, the whole surrounded by stars positioned at great distances from the earth. For more than a thousand years previously, we say, Ptolemy's theory held that the earth was at the center, and quite likely the students are told or led to believe that Ptolemy was wrong and Copernicus was right. Now, it is interesting that in our day-to-day concerns we still refer to the rising of the sun, its passage overhead, and its setting. That is, in spite of the avowed "correctness" of the Copernican theory, we still think in terms of the sun going around the earth. Furthermore, in one genuinely important application, with lives at stake, we find a professional preference for the viewpoint of a central earth. I am referring to celestial navigation, since aircraft and ships are navigated from a geocentric, not a heliocentric point of view.

Then what is the importance of the Copernican theory, if it is of use only to astronomers or physicists? Certainly, of major significance is its influence on western thought. Here is a conception which displaced man and his earth from a favored position in the center of the universe and suggested that the universe was enormously larger than previously contemplated. Among those who accepted this new concept, some were humbled by the recognition that man had fallen further from perfection, since he was no longer to be considered at the perfect center of a series of perfect circles as Aristotle had visualized him. Others were enthused at the possibility that removal of the earth from a central position called into question the whole idea that there was any center at all. Perhaps, as Bruno argued, even the sun was not the true center and the universe might be infinite, as befits a Creator of infinite powers. All this was at the time of the Reformation and much of it was unacceptable to Protestant and Catholic alike, but it stirred a pot which was already bubbling merrily along. Now that the boiling has died down, we have with us the residual effect—a philosophical view of man and earth as relatively small specks in the universe, not at all in a distinguished position, and depending upon one's personal philosophy and religion, as being either insignificant in the vastness of it all or being peculiarly favored by the Creator from among all the other possible worlds in the universe. In short, Corpernicus displaced the anthropocentric view we inherited from the Greeks and opened the way to modern outlooks of man's place in the universe. And yet we retain the Ptolemaic conception for more mundane use. Both have their influence.

Newton's contribution was even more influential. Taking the concepts of force and motion that had already been recognized by Galileo for terrestrial phenomena, Newton systematized these into a set of laws which are still basic for the physics of everyday events. With the aid of these laws, he derived a theory of universal gravitation and showed that the laws of nature pertained not merely to terrestrial phenomena but to the movements of heavenly bodies as well. The effects on society were immediate and are still with us: an extraordinary respect for the power of mathematical science even though the nonscientist does not always understand it, a taste for mechanistic "clockwork" explanations of the world around us, and a faith in the

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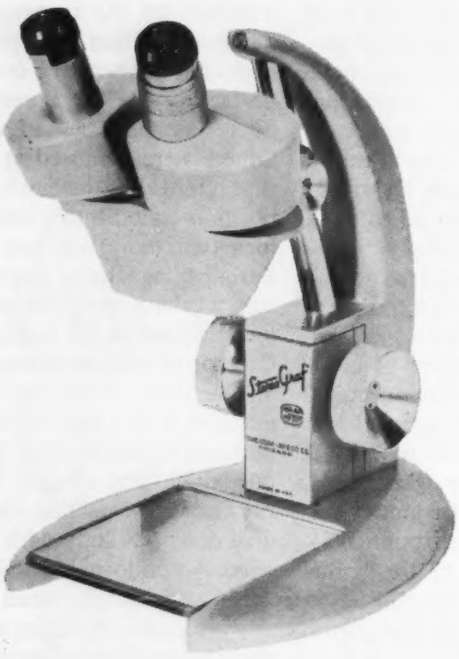

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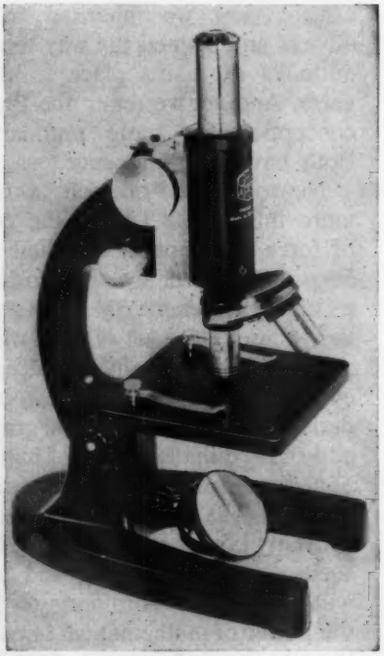

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existence of "natural laws" which, if only discovered, will clarify the unknown and guide our conduct in all fields of study.

One instance of these effects is particularly convincing evidence of Newton's influence: John Locke, philosopher and political theorist, announced that he had read Newton's works and, although his understanding was limited, he could appreciate the power of Newton's method. It was Locke who said that man has certain natural rights, among which are life, liberty, and property. He believed these rights to be comparable to natural law, and similar ideas about natural rights were held by Rousseau. Locke's statement is generally considered to be the direct ancestor of Thomas Jefferson's axiom on the unalienable rights to life, liberty, and the pursuit of happiness in the Declaration of Independence; Rousseau is credited with an equivalent seminal role in the French Revolution.

Just a little more than one hundred years ago, it was Darwin who produced an impact still resounding in western civilization. The idea of organic evolution with natural selection as its guiding mechanism stimulated thinkers far more than earlier evolutionary ideas had. Natural selection, conceived as the survival of the fittest, was and still is accepted by many as a natural law justifying wars, power politics, cut throat competition in business or love, compulsory sterilization, physical education programs, eugenics, and no doubt other phenomena of human affairs. In a more subtle way, the idea of evolution per se, whether or not guided by natural selection, has its effects, too. For it is so easy now to accept the Great Chain of Being or the Ladder of Nature as a rank order with genetic relationships. The organisms on the upper rungs are felt to be related to the "lower" organisms. But this implies that man is one of the animals, higher if one insists, but an animal nevertheless. Some cannot tolerate such an implication; they find it denigrating. Others find it logically and emotionally acceptable; it provides them, just as the Copernican theory did, with a satisfactory picture of man's position in the universe. Still others find the implication ennobling, for to them man emerges as an animal evolving from primitive origins to his present admittedly imperfect state but with promise of evolving nearer to perfection in the future. The point here is not, I think, whether Darwin influenced all of us in the same way, but that he did influence western thought. Like Copernicus, he helped us decide on our place in the "scheme of things," a scheme which seemed to be predominantly mechanistic, with a putative natural law controlling that mechanism and, by analogy, the conduct of human affairs.

My main thesis has been that one of our deeper objectives in teaching science is to orient our youth in western civilization. Although undoubtedly we could profitably slant some of our science teaching toward the history of ideas and the factors in the development of our culture, I will make a much more modest recommendation than that. Let us merely bear in mind that science has had profound influences on western thought, that the ideas from science which we pass on to students inevitably condition their outlook, and we should find it easier to justify to ourselves why we teach science. This, I submit, is the justification we need most of all, for it justifies the limited objectives of our day-to-day teaching.

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CHEMISTRY IN ELECTRONICS

By KENNETH L. ROHRER

Chemist, Westinghouse Electric Corporation, Elmira, New York

CHEMISTRY in electronics? Popular misconception implies that the electronics industry is composed mostly, if not wholly, of electrical technology. On the contrary, it is an industry with diversified processing techniques and exacting manufacturing standards which require the services of almost every type of scientist and engineer: chemists, physicists, ceramicists, metallurgists, to mention a few; and a considerable amount of *creativity* from each. The applications of chemistry in electronics have been and are becoming increasingly more important.

Chiefly responsible for post-war growth in the industry have been radio and television and increased government spending for products for the national defense. Such things as missiles and anti-missiles, space vehicles, supersonic extended-range bombers and fighter aircraft, communications, early warning detector screens, and computers have fantastic requirements for electron tubes, transistors, components, and gear. This steady industrial and economical growth has endowed the electronics industry with increased sales in both the new and renewal markets to industry and the home consumer, particularly in radio and television. These are areas of employment for many of today's trained scientists and engineers.

The functions of the electronics chemist might be classified within one or more of the following fields: chemical analysis, research and development, materials engineering and preparations, plant facilities and processes, and consulting services of various kinds.

Qualification for these jobs usually demands specialized academic training and a bachelor's degree in chemistry and chemical engineering. Further study for the doctorate degree is more requisite today than ever before. After formal training, continued study of the literature and technology is needed to keep abreast with latest developments. As in any science, intellectual curiosity coupled with imagination and creativity are some of the most desirable traits for

recognition of contributions by associates, superiors, and the public.

Chemical Analysis

The analyst's responsibilities are the development, application, and interpretation of analytical and statistical methods for analysis. His purpose is twofold.

First, the need for maintaining a high quality product must be satisfied. To insure this, many raw materials, whether they be metals, ceramics, glasses, plastics, or chemicals are qualitatively and quantitatively analyzed for composition and impurities. Analysis is also extended to troubleshooting and monitoring factory processes to provide smooth flow of materials and to avoid high scrap or costly shutdowns.

Second, the analyst serves to aid the research, design, and project engineers. The long step between the design board or laboratory and the successful application of an electronic device is often dependent upon analytical data and its interpretation. Data will provide invaluable information about such things as identification of materials or substances, both foreign or native to the device, and will provide a basis for logical and systematic deductions concerning physical and chemical mechanisms associated with processing and operating of the device. Thus, inherent design deficiencies may be recognized and eliminated before release to the customer.

Although the analyst's tools include the newest spectrographic, instrumental, microscopical, and wet methods of analysis, his problems are many.

His principal struggle is to avoid obsolescence by developing new and more sensitive instruments and methods for analysis; in the electronics industry this is a never-ending process. New and more reliable devices usually require additional new materials. The industry is unique in the number of different materials it uses. Its individual needs have already prompted a new designation for purer materials—"electronic grade." Purity is especially requisite in the manufacture of electronic tubes and transistors. And, of course, higher purity materials require more sensitive methods of analysis.

Research and Development

Research and development are the lifeblood of the electronics industry. New tubes, systems, and components require new ideas, materials, and various processing procedures.

Physical chemists, organic chemists, inorganic chemists, and electrochemists form a team bent upon creativity. The products of their creativity may be a final electronic entity for sale, but is more often a process or part of a tube or device which is more efficient, cheaper, or entirely novel to the industry. Without their support, the effectiveness of the electrical and mechanical designer may be seriously limited.

Today, for example, the electronics chemist in research and development finds his niche in such categories as the following, described briefly:

Electrochemistry

The trend is toward increased use of the rarer or uncommon metals, especially for high temperature design. To make use of their unique properties, chemists are developing new methods for electroplating on or with these metals. Practical methods for electroplating some of the more common metals, particularly in the refractory metals group, have not yet been achieved. Sometimes, because of their position in the electromotive series,

A new laboratory tool for the measurement of pressures less than one-thousandth of one-billionth of atmospheric pressure at the earth's surface has been developed by Westinghouse scientists. The device, known as a photomultiplier ion gauge, was developed as part of an ultra-high vacuum research program supported by the U. S. Atomic Energy Commission's Project Sherwood. Project Sherwood is a long-range research program aimed toward achieving controlled nuclear fusion for peacetime uses. The new instrument has advantages over conventional low-pressure-measuring devices for many critical ultra-high vacuum experiments. Ultraviolet light, shining into the gauge, releases electrons which are multiplied in number and used to form charged particles, or ions, inside the device.

difficult-to-plate metals are alloy-plated with other selected metals, deposited from fused salt baths, or plated from organic solvent electrolytes.

Efforts continue to modify or improve the physical properties of the commonly electrodeposited metals and to lower costs and improve operating efficiency.

The latest electro-techniques in metal finishing are being investigated and developed; for example, anodizing and anodic coatings, electropolishing of new and uncommon metals, and electrophoretic deposition of metals, ceramics, and plastics.

As an illustration, the purpose of electropolishing is to eliminate profile irregularities in metal surfaces by selectively dissolving projections and producing leveling and brightness.[1] It is a process much the same as electroplating, except that metal is dissolved rather than deposited. Here processed parts are made the anode rather than the cathode as in other research.

It is a process frequently in use today for deburring, reduction of oversized parts, and for producing a smooth or mirror finish where mechanical buffing is not practical.

[1] *Metal Finishing Guidebook-Directory*. Metals and Plastics Publications, Westwood, New Jersey. 1961. p. 447.

This specially designed vacuum induction furnace, glowing white hot in the materials laboratories of Westinghouse Electric Corporation, is used to prepare a new thermoelectric material—samarium sulfide. The new material is one of a family of ceramic-type, rare earth compounds which can convert heat directly into electricity at temperatures as high as 2000°F.

Electropolishing of metals, such as copper and tungsten, may be demonstrated to the student in beaker experiments. The piece to be polished is hung into an electrolyte between and parallel to two cathodes also immersed in the media. The work piece is connected to the positive and the cathode to the negative terminals of a six- or twelve-volt storage battery or dry cells through a variable resistor. To polish tungsten and copper, a lead cathode and a copper cathode may be used respectively. Small tungsten parts can be polished to a mirror finish in 20 per cent (by weight) sodium hydroxide at 6 volts (DC). A 3:1 (by volume) phosphoric-acid electrolyte at 6 volts (DC) will produce comparable results with similar copper parts. Before electropolishing it is suggested that the metals be degreased in boiling trichloroethylene, rinsed in clean methanol, and carefully dried to avoid other problems.

Resins, Coatings, and Adhesives

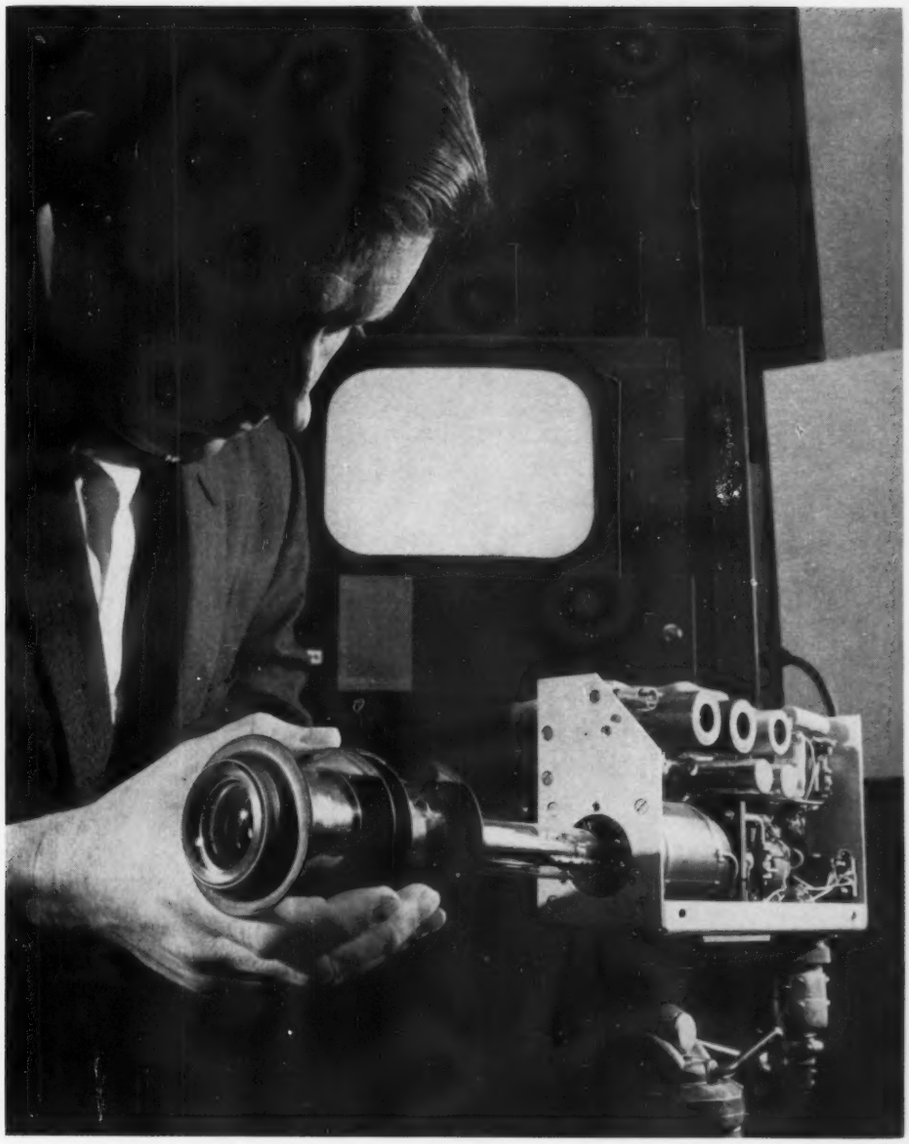
Electronic devices and gear are designed for service under a wide and varied range of conditions from the depths of the oceans to the heights of the outer atmosphere and beyond.

The huge numbers and inaccessibility of these components demand long life and reliability. Reliability is not only dependent upon the device itself, but upon appropriate protection against water, humidity, temperatures from sub-zero to several hundred degrees above, shock, and vibration. Potting and encapsulation have been a solution to the problem.

The chemist is responsible for the selection, formulation, and application of special protective materials—usually resinous organics or ceramics for encapsulation, potting and adhesive attachment of electronic tubes and components. Of considerable concern to him are the demands of higher temperature environments and reduced payload mass, particularly in space vehicles and aircraft. Future demands will fast obsolete present materials.

Luminescent Materials

A major use of luminescent materials or phosphors now exists in the manufacture of electronic tubes and devices such as cathode-ray, image intensifier, radar, storage, and Astracon tubes. In addition, many of the new solid state devices use them.



A new electronic imaging tube, placed on a vehicle in space, will enable scientists to learn more about the stars and the depths of interstellar space. Developed by scientists at the Westinghouse research laboratories, the tube is sensitive to the short-wave length ultraviolet light rays that are emitted by celestial bodies but never reach the surface of the earth since they are screened by the atmosphere. Called the Uvicon, the new ultraviolet-sensitive tube was developed for the Astrophysical Observatory of the Smithsonian Institute, Cambridge, Massachusetts, for the Observatory's Project Celescope.

Luminescence is a general term which includes the many phenomena involving the absorption of energy by a substance and its re-emission as visible or near visible radiation. Some phosphors are pure substances and self-activated, but most materials of high luminescence efficiency are activated and emit due to small concentrations of purposely added impurities. Small changes in types and concentrations of these activators reflect characteristic changes in efficiency, color, or related phenomena.

A simple demonstration will show the student how nonluminescent materials can be caused to emit radiations of varying colors depending upon the activator used. Under an ultraviolet light source, zinc sulfide and the double crystal of zinc cadmium sulfide[2] will show no luminescence; zinc sulfide activated with 0.02 per cent silver will emit a blue color; zinc sulfide activated with 0.01 per cent copper will emit a green to orange color; zinc cadmium sulfide with 0.02 per cent silver will show a yellow glow; and zinc cadmium sulfide activated with 0.01 per cent copper will appear as a greenish-yellow color clearly visible.

Phosphors for electronics are usually purchased from outside suppliers, but the chemist should remain aware of the latest developments in these products and of their potential application. Increased phosphor efficiency, resultantly higher light output, together with higher resolution, would be his main considerations for process development.

Intense interest of late has been shown in the application of so-called transparent phosphors. Although they presently offer high resolution capabilities, much is to be desired in efficiency.

More desirable have been electrophoretic techniques for laying down phosphor screens, as opposed to conventional settling or spray methods. Thus, improved resolution with no efficiency loss can be realized with the granular, opaque phosphors in wide commercial use because of the thinner and more dense layers possible.

Chemical Cleaning

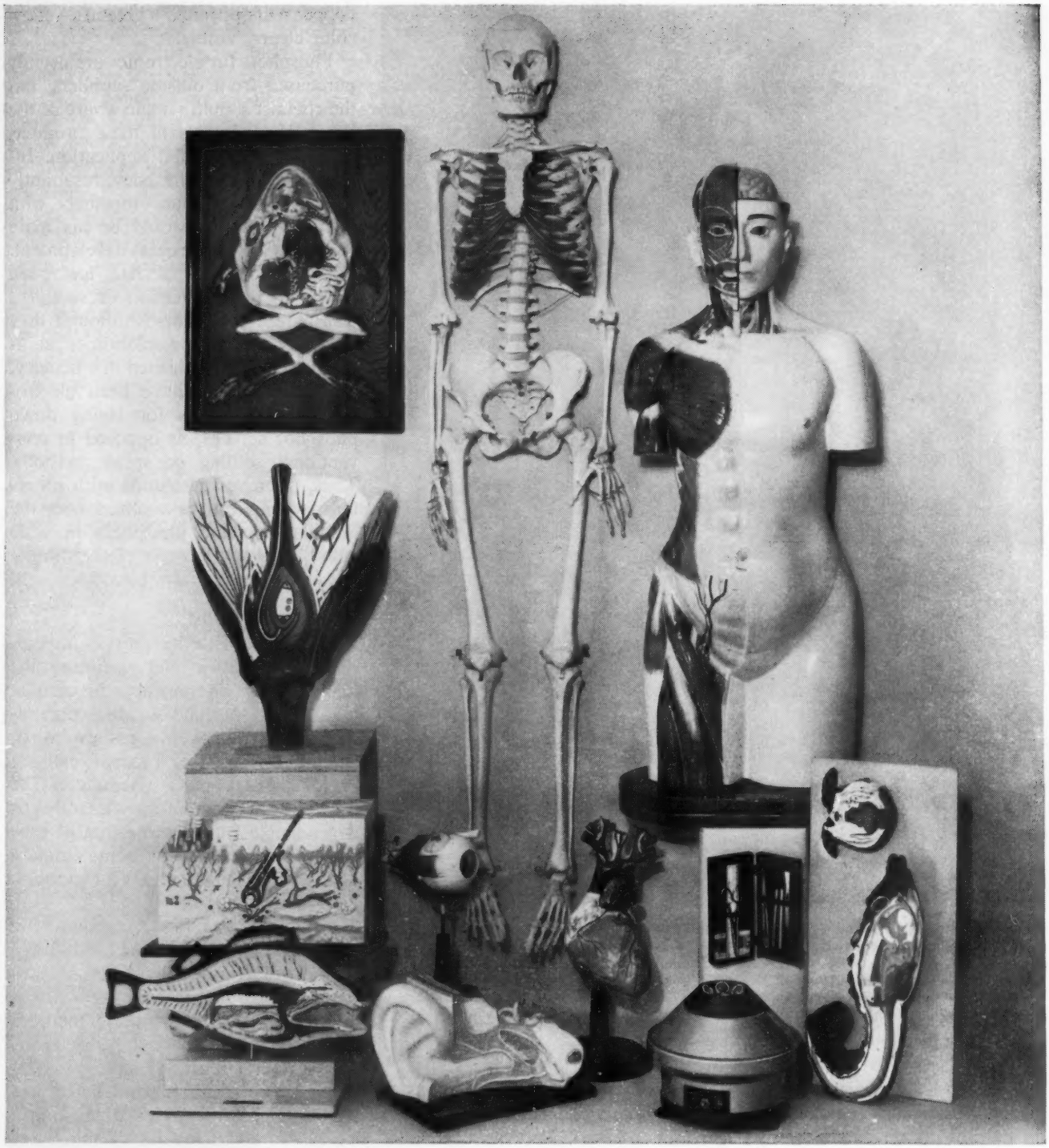
Cleanness of device parts is imperative in transistor and vacuum tube manufacture. For example in vacuum tubes, inorganic and organic contaminants are sources for gas evolution. The result is loss of vacuum, cathode poisoning, and finally tube failure. The reliability of long-life vacuum tubes is dependent upon the protection of tube parts from sources of contamination and upon efficient methods for contaminant removal.

Chemical cleaning techniques are being developed to remove all but a fraction of a molecular layer of contaminant. Combined with the advent of ultrasonic cleaning, these methods have been a boon to the industry. However, preservation of cleanness is contingent upon adequate storage and protection against further contaminants. To check and maintain cleaning and storage efficiencies, sufficiently sensitive tests are being devised and put into practice.

One such test, the water-break test, can be easily taught to the science student. This test is used for detecting monomolecular hydrophobic (nonwetting) films, such as greases and oils, on surfaces and in processing ambients.

It is performed by immersing the dry surface, for example a nickel strip, under test into a container of overflowing de-ionized or distilled water

[2] Samples available only from phosphor manufacturers or television tube manufacturers.



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and by withdrawing it in a vertical position. If clean, the draining water layer will remain as a continuous film over the surface. In areas where hydrophobic substances are present, the draining water layer will break up into a discontinuous film within one minute.

For control and standardization, a freshly cleaved mica sheet (minimum ASTM quality, V6, both sides), 1 × 2 × .015 inches or larger, should not show a water break after withdrawal. As little as one drop of a 0.05 per cent solution of oleic or stearic acid in acetone will clearly show demarkation between clean and contaminated areas. The length of time necessary for the water-break to occur can be used as a rough indication of the degree of contamination. It can be shown that a contaminated nickel strip can be cleaned by chemical oxidation for 20 minutes in a 3 per cent by volume solution of hydrogen peroxide (30 per cent by weight) in water at 90°C. Followed by thorough rinsing in de-ionized or distilled water, the samples will pass an immediate water-break test.

Cathodes

The cathode, by definition that electrode from which electrons are emitted, is the heart of the vacuum tube, and poor cathode performance causes adverse tube operation. Either heat, light, high electric fields, or kinetic energy of incident particles may be used to cause emission.

Emitter materials may be classified into pure metal cathodes, film cathodes, composite cathodes, oxide cathodes, dispenser cathodes, and matrix cathodes.[3]

Although much has been learned in the last few years, more needs to be known about the reaction mechanisms of old and new cathodes alike. These mechanisms involve both chemical and physical phenomena.

Cathode design requires a fundamental knowledge of the physical and chemical properties of many materials. After selection and design of a theoretical system, laboratory preparation of materials of a chemical nature is usually necessary, cathode fabrication and exhaust processing schedules are developed, and the work function or emitting efficiency measured.

After many experiments and life-test data with new materials and systems, a new cathode of practical commercial design may be realized. Reliability with increased life is the mother of the invention.

Semiconductors

Recently, semiconductor materials have been expanded into thermoelectric, photoconductor, infrared detector, and other device applications. Expanded lists of semiconducting compounds are being made available. Compounds likely to be semiconductors are being chemically synthesized and their properties measured.

From these, arrays related to the Periodic Table of the Elements can be prepared.[4] Arrays aid in estimating the physical, chemical, and semiconducting properties of compounds suspected to exist—some of which may not exist.

Only silicon and germanium in the transistor field, as yet, have achieved major commercial significance, but their manufacturing costs are high.

Improved processes for synthesizing germanium and silicon are being developed. New refinement or purifying techniques and the growing of single crystals have contributed to a more thorough understanding of the electrical, chemical, and mechanical properties of solid state materials. Typically no more than one part of foreign material in 100-million parts is permissible. With high purity materials, distribution or "doping" with the proper type of atoms is effected to obtain the desired characteristics.

These and other manufacturing finishing steps, many of a chemical nature, are being examined, developed and modified, and applied to reduce costs and extend reliability.

Materials Engineering and Preparation

The design engineering of electronic materials and processes for construction is a constant problem to ensure the right material to do the right job. Final selection is dependent upon their chemical and physical properties and their performance determined by evaluation in their intended environment.

The large variety of materials required, even for a single device, disciplines the chemist to accumulate a familiar knowledge of presently available materials, where they can be acquired, and their design capabilities. He must also continue to review the literature for recent innovations in the materials and process field and work in close coordination with the research and development staff.

When so highly specialized that the material cannot be obtained elsewhere in the desired state or purity, there is no alternative but to synthesize it first on a small laboratory scale. Frequently, material needs are small, but the variety of chemical specialties enormous for present-day research.

Whether a matter of selection, testing, or synthesis of chemical materials, the knowledgeable judgment of the chemist is invaluable.

Plant Facilities and Processes

Contained within the average electronics plant are many unit processes and operations to warrant the control and supervision of the "true chemical engineer." They include provisions for service utilities—gases, water, power, wastes, etc., and actual synthesis and

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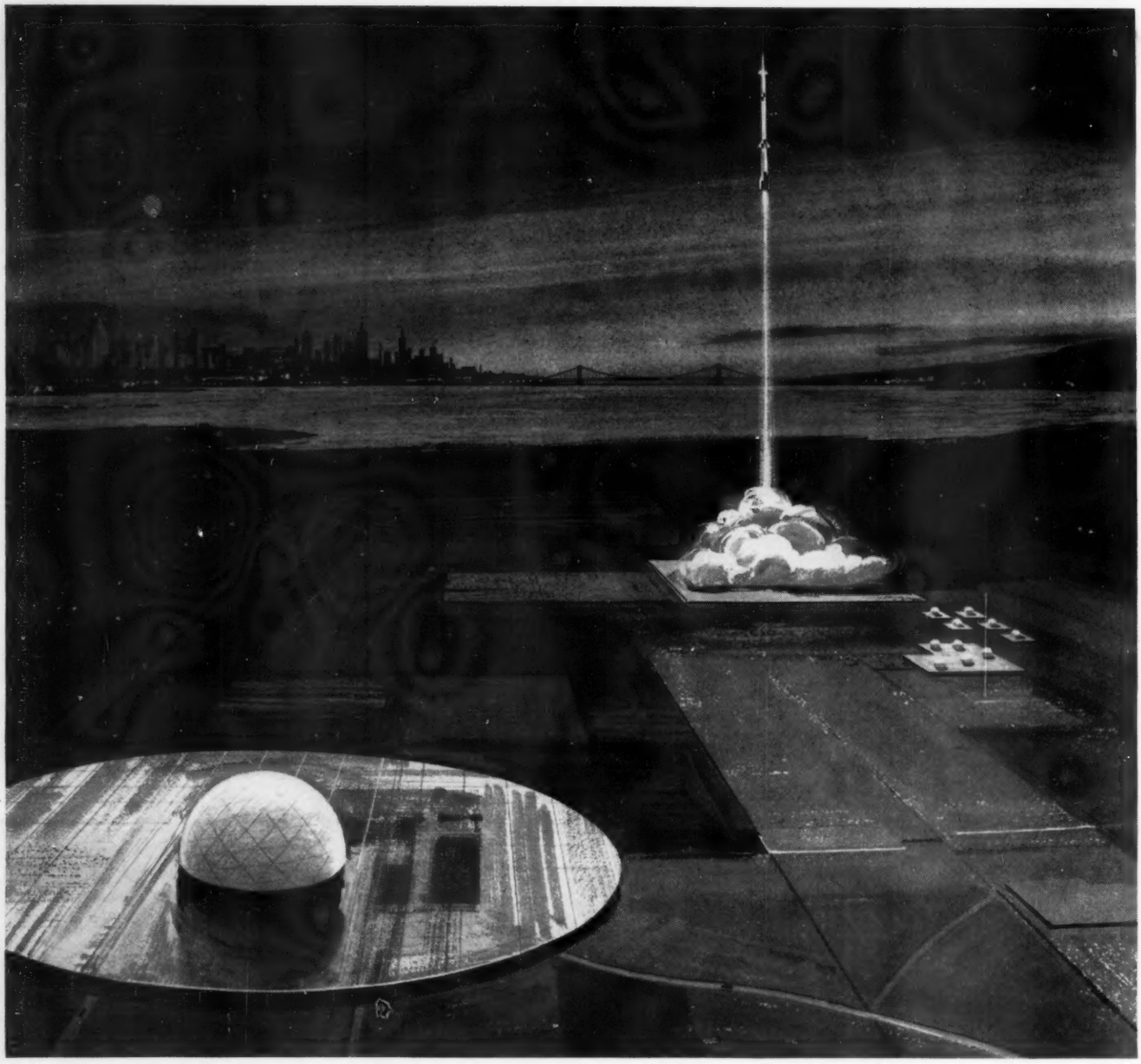
[3] W. H. Kohl. *Materials and Techniques for Electron Tubes*. Reinhold Publishing Corporation, New York. 1960. p. 520.

[4] A. J. Cornish. *Journal of the Electrochemical Society*. 106:685. 1959.



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The system tracks the ICBM or IRBM, then launches and tracks the Nike Zeus missile and automatically steers it all the way to intercept the target. The entire engagement, from detection to destruction, would take place within minutes and would span hundreds of miles.

Under a prime Army Ordnance contract with the Western Electric Company, Bell Laboratories is charged with the development of the entire Nike Zeus system, with assistance from many subcontractors. It is another example of the cooperation between Bell Laboratories and Western Electric for the defense of America.

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formulation of chemical specialties on a larger than laboratory basis.

Of the service utilities, water purification and treatment of chemical wastes have been of considerable importance. High purity electron device materials require and use new techniques for obtaining the highest of purity low-conductivity water free from solubles and suspended matter in the sub-micron range.

An experiment can be prepared to show some of the methods used in the industry to examine and remove particles of colloidal size or larger from seemingly high quality water. Colloidal particles are too small to see with a microscope. They can, however, be detected by other optical means. If a strong beam of light is passed through a medium containing particles $<10^{-7}$ cm the path of light cannot be easily detected. If larger particles are present, e.g., colloidal particles of 0.2 μ and larger, they will scatter light and render the beam visible, producing what is known as the Tyndall effect. Individual particles will become apparent as flashes of scattered light. This beam can be provided with an ordinary slide projector and its lenses and a small aperature diaphragm for viewing.

It may be seen that from such examination de-ionized water and double distilled water obtained in the laboratory by ordinary techniques are still contaminated with suspended particles of varying size, although they may have electrical resistances up to 18,000,000 ohms/cm. After filtration through such media as ordinary filter paper, fritted glass, porous metallic filters, and fiber filters, the student will discover that these particles are still there, and in some cases in larger numbers and size than before from further contamination.

Fortunately, there are available thin cellulosic porous membrane filters[5] in porosities of ten millimicrons to five microns which offer absolute retention of particles larger than their respective porosities. Use of these filters will aptly show efficient removal of suspended contaminants.

Continued operation of any plant is dependent upon effective treatment and discharge of chemical wastes. Restrictions and tightening of state requirements in many cases have compelled modifications in present disposal processing and the need for new, high volume waste treatments.

Consulting Services

Lastly, there is the area of consulting, usually for the more experienced chemist who through the years has acquired a storehouse of knowledge concerning chemical problems and techniques associated with electronics. He may be strictly a specialist in a limited field, or conversely, his experience may encompass a wide diversity of chemical subjects and aptitudes. You might find his title typically to be Advisory Engineer.

Under his advisement and consideration are the day-to-day problems confronting the project engineer and his development program, the problems for immediate solution of the front line engineer or foreman, or the relatively long-range planning associated with the design engineer. Consultations can usually eliminate in short order stumbling blocks, seemingly insurmountable to the chemically untrained, but routine to the chemical specialist having a similar experience.

[5] Available from Millipore Filter Corporation, Bedford, Massachusetts, or Gelman Instrument Company, Chelsea, Michigan.

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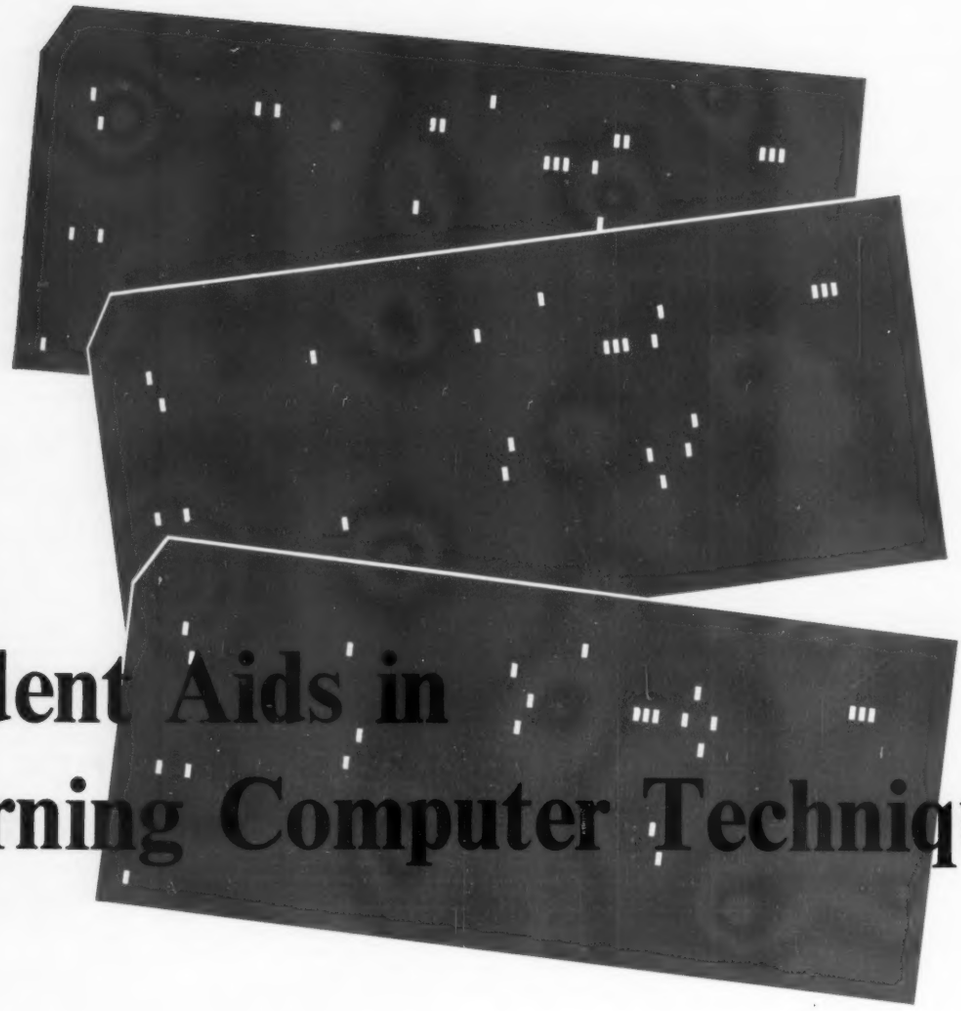


Student Aids in Learning Computer Techniques

By HAROLD V. McINTOSH

Research Scientist, Research Institute for Advanced Study, Baltimore, Maryland

PUZZLES and brain teasers have proved to be effective devices in teaching young scientists to use electronic computers.

An experiment was conducted at the Research Institute for Advanced Study, the Martin Company's basic research institute, which sponsored the course in computer programing for students. The Institute was one of three held on the campus of Morgan State College, Baltimore, Maryland, during the summer, the other two being courses for high-ability high school students and for high school teachers of mathematics and science, sponsored by the National Science Foundation.

Twelve students—from high school seniors to graduate students at Harvard University, Cambridge, Massachusetts —attended the eight-week course. All students, whose ages ranged from 17 to 23, were gifted in mathematics.

In this course, it was my intent that we be concerned primarily with the use of the computer in solving logical, rather than numerical problems. An example of a numerical problem is the computation of the payroll of a large company; a logical problem would be a search for the symmetry characteristics of a complicated chemical molecule or related problem.

It was found that students in writing solutions to puzzles developed a sharply increased awareness of the potentialities of the computer as an instrument of logic.

Computers solve problems, whether logical or numerical, in accordance with directions given them in a program, which is a sequence of steps expressed in language the machine can understand.

Good programing techniques enable human beings to utilize the high reliability and the enormous speed of the

machine. The electronic computer can perform a hundred thousand calculations in a second and can solve a differential equation in five minutes that would take a man five years, assuming he could work that long without making an error.

Students have already written programs to solve the Tower of Hanoy and the Chinese Ring puzzles, which provide interesting exercises in logic. Others have written a program that will enable the computer to solve the popular "cannibal-missionary riddle."

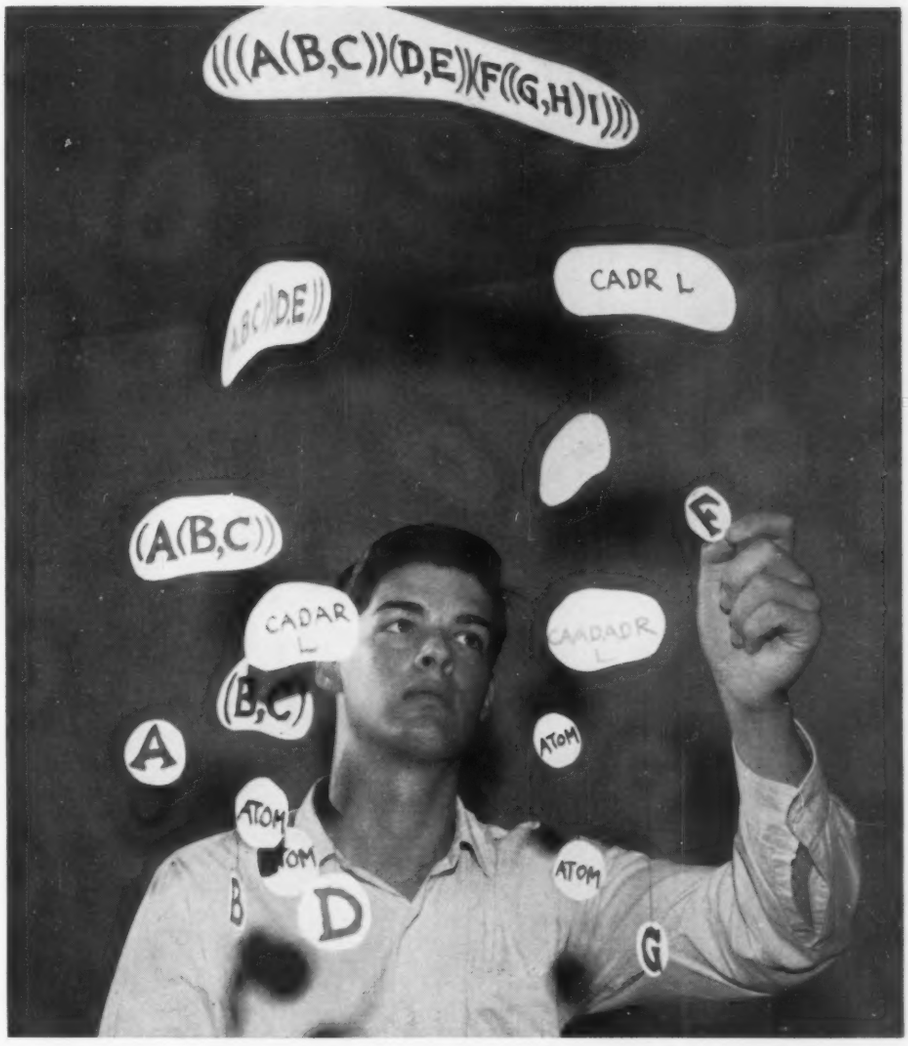
The solution of puzzles is by no means an end in itself; it is only one of several approaches whereby students acquire an understanding of computer techniques.

Some students worked on programs of a purely mathematical nature. One wrote a program to simplify algebraic expressions, another to calculate derivatives and to evaluate determinants symbolically.

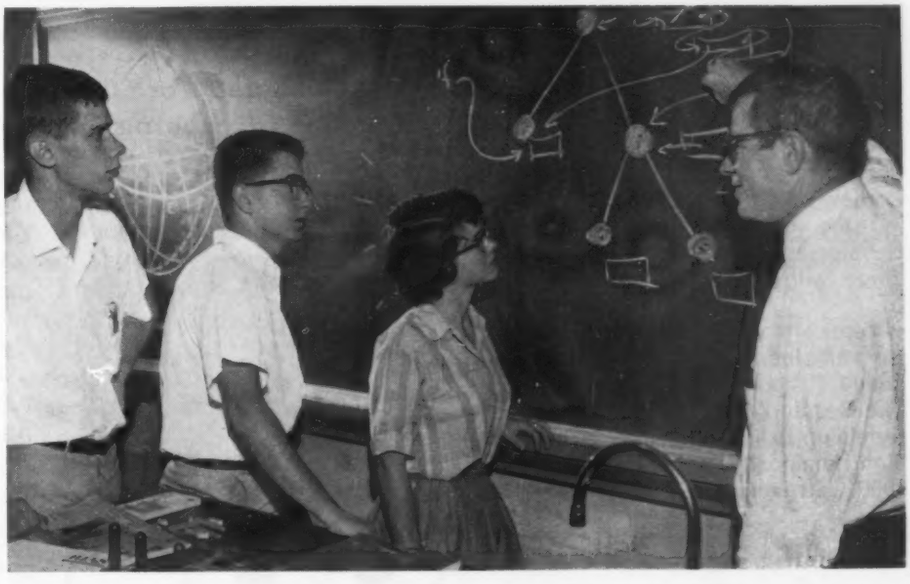
Other students concentrated on the study of specific functions that certain types of programing can perform. The programing techniques studied most intensely during the course were LISP (a list processor developed by Professor John McCarthy, of the Massachusetts Institute of Technology, Cambridge, and his students); FLT (the Fundamental Logic Translator being developed by the author); and SOS (SHARE Operating System, developed by SHARE, an association of users of IBM equipment).

One of the most interesting projects was a handbook of LISP functions started by the students. Work on the handbook will be continued in next year's summer course. Already over sixty LISP functions have been defined and their mode of operation described first in English and then in "machine language."

Another benefit of particular importance has been a more complete development of certain facets of FLT. Many of the ideas were contributed by students, and part of the code was written by members of the course.



Mobile for Computing. Peter Conrad, 18, of Fork, Maryland, a student at Yale University, New Haven, Connecticut, studies a mobile he built to help him visualize the structure of lists, a fundamental concept in understanding the logical use of electronic computers. The unit he is holding is an atomic symbol, one single basic entity. A list is made up of a collection of symbols or of other groups of symbols. The mobile was built by Conrad while attending the seminar in computer Theory and Applications.



Class for "Computers." Harold V. McIntosh, author (r.), explains list functions to Dan Hartline, 21, of Hydes, Maryland; John Baildon, 17, of Dundalk, Maryland; and Judy Barnes, 19, of Chambersburg, Pennsylvania; (l. to r.).

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One of the students has prepared a portion of FLT which will allow a person to use headings whose form indicates the portion of the program in which they belong. For instance, a simple decimal nomenclature permits one to indicate that portions of the program follow in a definite sequence, whereas other forms of the notation indicate which of several alternatives the program should choose.

Other students have done some very interesting work to illustrate the program, in particular the preparation of a flow chart to accompany it. This allows a person to see at a glance a current version of the program which he is preparing. Besides its use in FLT proper we expect such illustrative programs to be very helpful in increasing the understandability of the output of programs.

One student, a high school graduate who worked for us for six months while awaiting the fall term of college, prepared a program which takes a group table for a small finite group in normal form and makes an exhaustive analysis of the subgroups, classes, and normal subgroups of the given group. As an example, we have used this program to analyze the nonabelian groups of order 16 which shows a number of interesting similarities and differences among them.

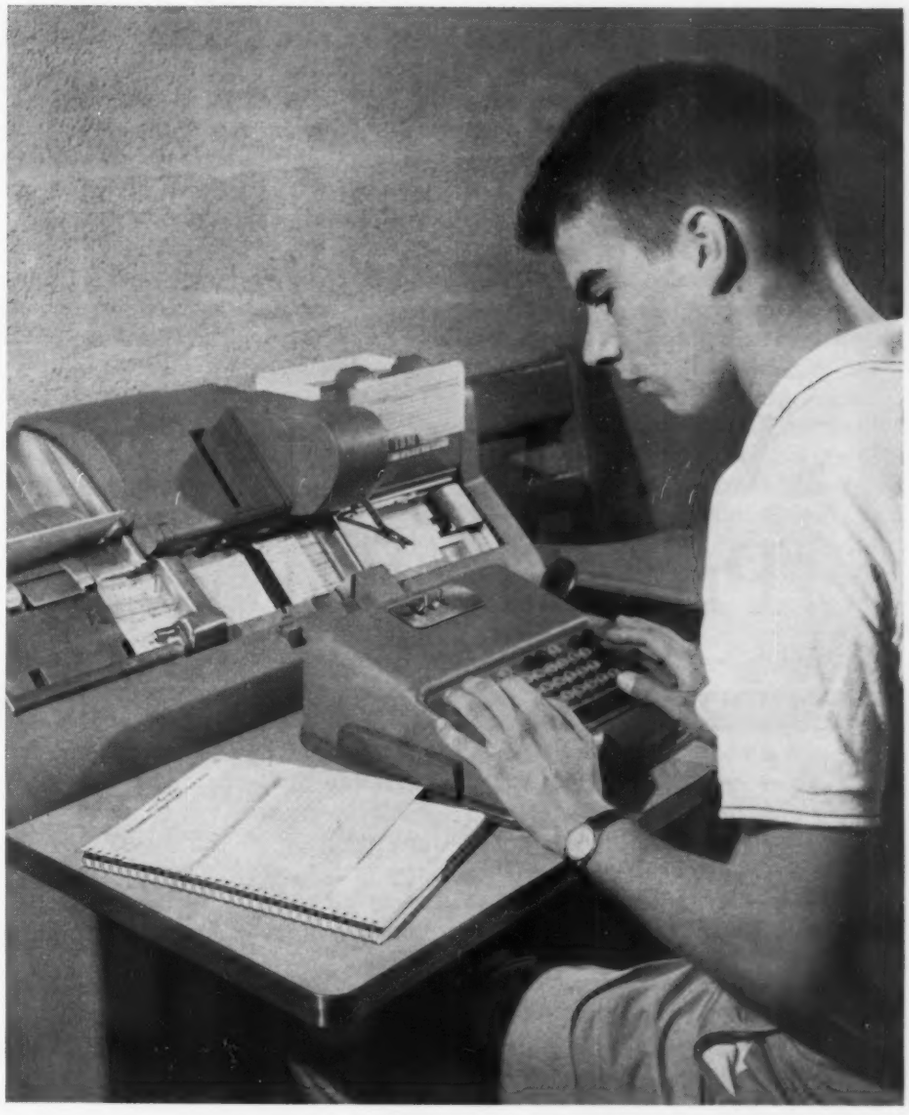
The heart of the classroom sessions was a series of lectures which I gave on group theory and matrix theory and fundamental mathematical concepts, as I regard these as essential to understanding the logical potentialities of the computer.

For four hours each morning students attended these lectures and others by guest lecturers, such as Eduardo R. Caianiello, Chairman of the Institute of Theoretical Physics at the University of Naples, Italy, who described his work with "thinking machines."

In the afternoons the students worked on problems assigned to them and on special projects of their own choosing.

A keypunch in the classroom provided students with the opportunity to write their programs which were then processed at the Martin Computation Center on the IBM-7090 computer.

Dan Hartline, 21, a 1961 graduate of Swarthmore College, Swarthmore, Pennsylvania, says the course will be useful in his graduate studies in biophysics at Harvard University, Cambridge, Massachusetts. The only college graduate in the course, he has been able to write programs in LISP, SOS, and FLT.



Key to Programing. William Skeen, 17, of Arbutus, Maryland, used a keypunch to prepare a program for the IBM-7090 electronic computer.

"The idea of using computers logically is difficult to grasp from manuals," said Dan. "It is better to work with someone who knows the possibilities. Then you just sit down with a program and figure out what it does."

Even though the idea of using a logical instrument to supplement one's reasoning is a concept of long standing, it was not until electronic computers were developed about fifteen years ago that we had any practical means of realizing the possibilities now becoming evident from various research results.

By contrast, the use of the computer for numerical purposes dates back thousands of years to the invention of the first "computer," the abacus of ancient China and Egypt.

From my undergraduate work in physics and then to graduate work in mathematics, at Cornell University, Ithaca, New York, my interest has been in the field of theoretical quantum chemistry. The interest in computing has evolved from my efforts to find more effective techniques for solving problems in this field. I believe the devices noted here will provide additional tools to aid teachers and scientists in their use of computers.

These machines have no imagination at all. They are very literal. The only way to make them less so is to have more imaginative people use them.

Why Not Try the Problem Solving Approach?

By **CLAIR W. ELMORE**

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THE Northern California Committee on Problem Solving in Science (NCCOPSIS) was organized as one of two efforts to encourage teachers to form study groups in science education. Problem solving, as an approach in the teaching of science, was selected as the initial area for study during the first year of operation.

A review of the available literature on problem solving revealed that various writers presented many logical analyses. Little, however, had been written about the classroom implementation of problem solving as a goal of science teaching.

In the second year, we invited members from the California Science Teachers Association to join the study groups. Plans included a request from each member to send in examples of classroom situations applicable to problem solving-teaching. Evaluation of the examples sent in disclosed that most of the contributions were diverse and incomplete. We found from the results that we needed to extend and develop our teaching skills in this particular area.

NOTE: The interested response of members to the report of this exciting study, when presented at the NSTA 1961 Chicago Convention, has prompted publication of this article for the benefit of all teachers.

Thus began the framework in which the committee began its third year of work. The examples that had already been evaluated were revised and restructured to give practical problem situations. In hammering away at these examples, the Committee developed considerable skill in identifying and appraising possible problematic situations in the classroom. Every example was studied critically and intensely by the study group, no preferences were given to contributed material.

In the fourth year, the committee decided to collect the restructured examples in publication form to distribute to other teachers in science. These plans did not materialize because of lack of funds, but the committee prepared a limited number of mimeographed copies and distributed the material under the title, "Problem Solving in Science Teaching." Considerable requests for the material necessitated a second run. Finally, a book publisher became interested in running the material as a series in a service bulletin.

The Committee activities later focused on NSTA Convention plans at which major sessions were held. In the current year, the seventh, attention is being directed to the development of tests which will measure the effectiveness of our efforts to teach students to be problem-solvers in science.

What Problem Solving Means

Out of these years of exploratory sessions the NCCOPSIS Committee has derived the following from its observations:

1. As a cultural asset, science has two main facets, the attitudes of mind

and the skills in problem-solving methods by which scientifically-minded people have for many centuries sought to understand and control the world around them with some degree of intelligence and insight, as well as the fund of generalizations, concepts, and facts (information) which these methods and attitudes of mind have enabled man to develop. Both of these facets are of prime importance in science teaching at every level.

2. Scientific attitudes of mind and well-conceived methods of solving problems are as applicable to personal-social problems as they are to problems of the physical environment. As one committee member remarked, "It is not the problem itself, *but the method of solving it,* which is scientific in character."

3. No one step-by-step procedure in attacking a problem can be singled out as the Scientific Method, although certain elements of method have been found to be common to a variety of scientific problem-solving procedures (recognizing and clarifying the problem, gathering appropriate information, setting up hypotheses and testing them experimentally if possible, isolating the experimental factor by means of a control, running check experiments, making careful measurements, organizing and interpreting the data, drawing suitably qualified conclusions, and others). The number of steps involved, and the order in which these various elements of methods may occur in any given situation, will depend on the nature of the problem and the background of experience and insight that the problem-solver brings to it.

4. Of even more importance than method is the "spirit of science" (scientific attitudes of mind) which motivates the individual. These attitudes ultimately determine the methods he will choose and the standards he will set for himself in pursuing the solution of a problem (sincere curiosity as to causes-and-effects, respect for others' opinions, tendency to entertain honest and reasonable doubt in accepting dogmatic or unsupported statements of fact or personal beliefs, desire to be accurate in observations, willingness to hold conclusions as tentative and to suspend judgment until sufficient facts have been secured, habit of planning before executing a problem-solving procedure, etc.).

5. To develop in an individual a reliable disposition to use scientific methods whenever he attacks one of his problems, he must have had repeated opportunities to *experience* such procedures. Problem-solving skills cannot be taught by simply "talking about scientific methods" as a topic in a textbook; they must be *practiced* repeatedly in real problem-situations under the guidance of a sensitive and capable teacher.

6. A problem for a student is not necessarily inherent in any given question, interesting and exciting as it may seem to the teacher. The *problem* as such must spring to life in the mind of the student; and the teacher can do no more than create situations which challenge and tantalize, leaving questions unanswered perhaps, and manipulate and encourage the student's thinking to the point where he accepts the problem as his own. In the same sense that a fishing lure is not a lure unless it attracts fish and induces them to strike, a problem is not a real problem unless the student has an unanswered quandary, puzzle, or question in his mind and feels enough concern about it to want to seek a solution by whatever means his ingenuity and insights may permit.

7. The teacher's role becomes one of guidance, of seeking to get the measure of each student's thinking, and calling his attention to unrecognized sources of error, false assumptions, and other deviations from good practice which he must become aware of and correct before he can become skilled in scientific problem solving.

8. The best problem solving occurs when the student is self-motivated and on his own, free to try out hypotheses, explore ideas, and make mistakes. As a committee member once pointed out, he is spending most of his time in planning, defining, exploring, investigating, re-working, trying out, making judgments, gathering data, appraising, organizing, interpreting, evaluating, applying, cross-checking, observing, and experimenting.

9. The teacher should focus both the demonstration-discussions of the classroom and the work being done in the laboratory directly on the problems the students are solving, making the classroom and the laboratory both mutually supporting aspects of the same enterprise.

10. To succeed in problem solving, a student must be able to organize his science facts into meaningful relationships, as new concepts, principles, and generalizations. This is a time-consuming endeavor, and a highly personal one for each individual, requiring an atmosphere or "climate" that is permissive, allowing the student considerable free choice in organizing and conducting his researches. The teacher, the student, and the parents must accept the fact that technological advances of the past two decades alone have made it humanly impossible to "cover" any given field of science within the scope of the high school curriculum. Instead, data-gathering becomes a common activity, both in the classroom and the laboratory, directed toward the solution of actual problems in science. Estimating the probable error in mensuration and computation becomes a positive factor that students must bear in mind in gathering and interpreting such data. In fact, the *precise right answer* then is recognized as a hypothetical point more to be abjured than striven for in evaluating one's results in gathering scientific data, and we should look askance at exactly right answers when the measuring instruments are crude and chance errors are inevitable.

11. The student needs to discover his errors, select his data, weigh his evidence, and make judgments on his own. When experiments are conducted with the expectation that all students will get identical answers, the aim is quite unrealistic, if not scientifically dishonest, and discourages rather than encourages real problem solving. It is also unrealistic to expect all students to proceed at the same rate and to arrive at an answer together on any given day. Problem solving is a highly individualistic matter, and cannot be effectively regimented.

12. Teachers should make students familiar with the general aspects of the methods and procedures of scientific problem solving—through description and discussion, actual demonstration (perhaps role-playing), and first-hand practice in complete acts of solving interesting problems, working at a level consistent with the students' command of the subject matter. Students should be shown how to seek needed information in publications, how to tabulate and interpret data, how to increase accuracy of measurement, how to

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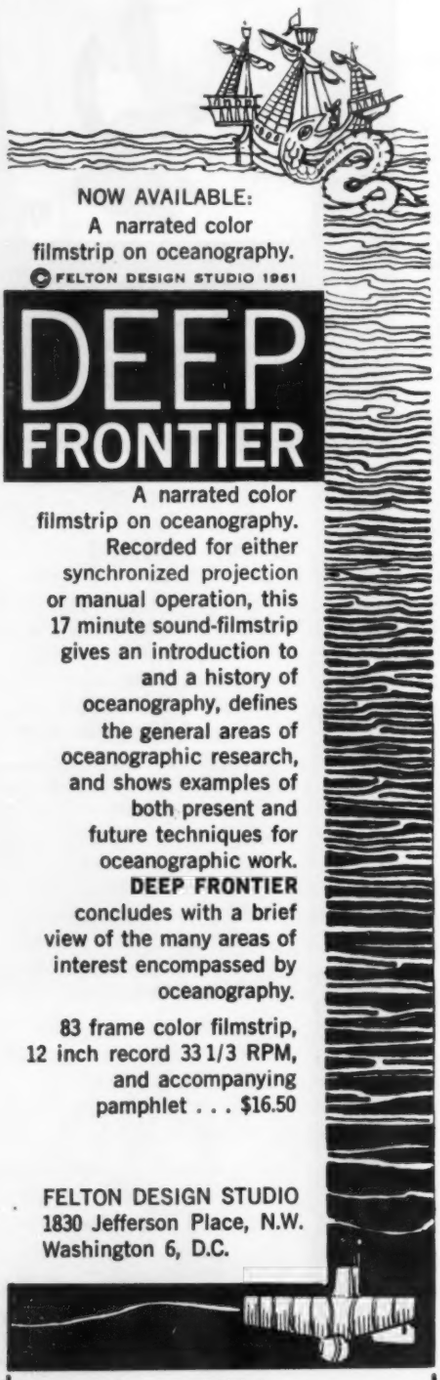
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establish suitable controls in experimentation, and how to cope with other procedural problems inherent in scientific problem solving.

Problem Solving in the Classroom

To indicate how the NCCOPSIS study sessions bore fruit, through sharing ideas, mutually criticizing them, taking them back to home high schools to be tried out, and reporting the results as soon as they were known, the following example is offered as an illustration of how both the teachers and their students entered into a creative effort to solve a problem scientifically.

At one of the NCCOPSIS meetings, Teacher "A" suggested a demonstration problem. Two 100-ml beakers are placed side-by-side inside a wide-mouth coffee jar, one containing 50-ml distilled water and the other 50 ml of saturated salt water. The lid is screwed on, making the system airtight. The class is challenged with a problem:

> I have noticed that, over a period of time, the water level in one of the beakers lowers and the other rises, until one is empty and the other is full. In which direction do you think the transfer takes place—and WHY?
>
> If you get any ideas that might be helpful, write them down and hand them in. If you can devise any experiments to shed further light on the matter, do so either here or at home—but let us know what you try, and what happens.

At the next meeting a month later, Teacher "B" reported that thirty student comments were turned in, none fully adequate but all did show some thinking on the problem. Student "A" had set up a similar jar in the laboratory, adding a third beaker of chemical pure dry salt, to determine whether or not salt "draws" water to it. The books say that salt is not deliquescent.

At the end of another month, Teacher "B" reported that Student "B" had set up apparatus of his own devising, to test whether other similar but separate systems reacted in the same way—H_2SO_4 and water; acetone and water; salt water and water; and NH_4NO_3 and water; and the student was photographing the systems each month to record results.

Teacher "C" reported that his class had become interested in other relationships in addition to the one demonstrated: The water cycle in nature, kinetic theory, evaporation, condensation, solution, polar and nonpolar molecules, volatility, and equilibrium. Questions raised included:

> Would the same thing happen if another liquid were used in which the salt is not soluble?
> Would it happen faster if it were alternately heated and cooled?
> Would it happen at all if kept at the same temperature?
> Could it be reversed?
> Does it require energy from outside the system?

Stimulated by these results, Teacher "A" offered an experimental test on "Scientific Observation" (based on the foregoing demonstration), and invited the NCCOPSIS people to use and evaluate it:

> On the basis of your experience in watching the Diffusion Experiment for a long time, mark each of the following statements with a *plus sign* if you feel it is related to the experiment, or with a *minus sign* if you feel it is unrelated to the experiment. After each statement, tell briefly *WHY* you marked it as you did.

1. Water "prefers" to be in a beaker.
2. Salt somehow "attracts" the water.
3. Water somehow "dislikes" being with salt.
4. Water is more volatile than salt.
5. Salt is more volatile than water.
6. Salt water boils at a temperature lower than fresh water.
7. Fresh water boils at a temperature lower than salt water.
8. Salt and water molecules attract each other more than water molecules attract each other.
9. Water molecules attract each other more than they attract salt molecules.
10. Water condenses more in the fresh-water beaker than in the salt-water beaker.
11. Water condenses more in the salt-water beaker than in the fresh-water beaker.
12. The surface of the fresh-water is colder than that of the salt-water beaker.
13. The surface of the salt-water is colder than that of the fresh-water beaker.
14. The surface of the fresh-water is colder than other areas in the system.
15. The surface of the salt-water is colder than other areas in the system.

16. In your own words, give any other explanations or ideas you have, that might explain the phenomena you have observed.

Two years later, Teacher "B" reported that Student "B," then in college, returned to visit the high school expressly to view his long-term experiment, which is still running in the laboratory and producing continued interest in the results.

Chain Reactions in the Problem-Solving Approach

The foregoing example, a simple illustration, sprang from an idea which one teacher found in a twenty-year-old book. It proved to be a thought-starter, which he shared with other teachers in the NCCOPSIS group. When his colleagues tried the idea out in their classrooms, they found their students adding to it creatively, ramifying it in many unexpected ways, and inventing apparatus and experimental approaches with which to seek answers to further questions. These student-developed ideas were soon fed back to NCCOPSIS, stimulating other teachers to explore the problem-solving possibilities inherent in the simple demonstration. Even this relatively insignficant experiment, running as it did for a long period of time, repeatedly raised questions in the minds of both student and teacher about other energy relationships in the system that had not been explored. The problems raised were usually difficult enough to challenge, but not so difficult as to frustrate, experimenting students.

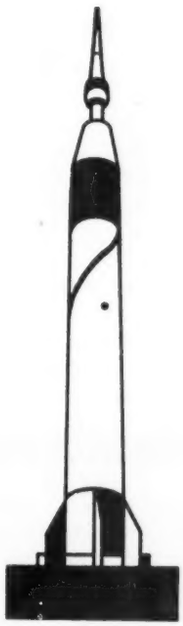
This simple, but long-term diffusion experiment impressed many teachers and their students with the superiority of the problem-solving approach in contrast to the text-and-lecture approach to science teaching. Both felt a quickening of interest and responded to the thrill of the challenge presented by the problem, a welcome relief from the tedium of assigned lessons-to-learn and facts-to-memorize.

Such situations provide opportunity for both team and individual research, with a wide range of ability and interest. Individualized instruction becomes feasible to a much greater extent and under the most natural circumstances. On the other hand, answers and outcomes cannot be easily predetermined. Not even the total diversity of the problems that will evolve can be anticipated. Certainly, there will never be a dull moment; and most importantly, students will be induced to *think!*

Conclusion

The science teachers who have participated during the six-year existence of NCCOPSIS are completely sold on the spirit and philosophy of the group, deriving great benefit and satisfaction from association with this type of professional committee, spontaneous and relatively unsponsored as it is. Should the group become so large as to be unwieldy (attendance usually runs from twenty to thirty per meeting), the California Science Teachers Association, Northern Section, is considering the organization of additional committees or study-groups, to parallel the work of NCCOPSIS in other areas of professional concern.

We hope that those who read this article will feel encouraged to call together similar spontaneous interest-groups in their own locality. In any event: "If you have problems,—why not try the problem-solving approach?"



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TENTH ANNUAL CONVENTION

San Francisco, California — March 9-14, 1962

Basic to the planning committee's design of the San Francisco convention were two strong convictions: first, that "the learner" should be the focal point of all considerations; second, that *all* convention participants should share in helping NSTA to frame policy guidelines for Association attitudes and activities.

Pursuant to the first of these, "Science Teaching for the Learner" is the convention theme. Speakers, panelists, exhibitors, and other participants have been alerted to aim at this target.

The second goal will be approached through a three-phase sequence of sessions culminating in a set of recommendations and proposed resolutions which will be presented and discussed at the final general session. The build-up to this session will begin with panel discussions in five areas of concern in science teaching: (1) Curriculum, (2) Staffing, (3) Programing, (4) Instructional Materials and Facilities, and (5) Evaluation. Opportunities for everyone to help probe all facets of these problems and issues will be provided through approximately 30 discussion groups. Next, the area panels will reconvene to crystallize the consensus of the discussants in each area. The convention Resolutions Committee will be in charge of this phase. Next, the results of these deliberations in all five areas will be submitted and evaluated in the sixth or final general session.

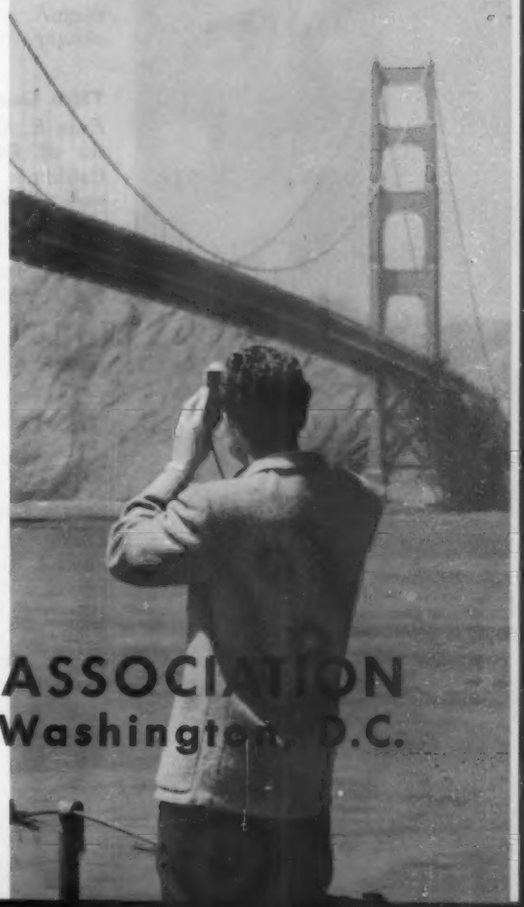
Outstanding speakers have been scheduled for four general sessions, the banquet, and all special luncheons. Ralph W. Tyler, Executive Director of the Center for Advanced Study in the Behavioral Sciences, Stanford, California, will address the first general session. He will discuss *"Forces Redirecting Science Teaching."* At the second general session, Robert W. MacVicar, Vice President of Academic Affairs at Oklahoma State University, Stillwater, will speak on *"New Frontiers in Science."* The address at the third general session, *"The Learning Process and the Teaching of Science,"* will be given by Evan R. Keislar, Associate Professor of Education, University of California, Los Angeles. At the banquet, considered as the fourth general session, Emilio G. Segrè, Professor of Physics and Nobel Laureate, University of California, Berkeley, will speak on *"The Antiproton."*

The fifth general session will feature a symposium on curriculum development. The three speakers in the symposium include Donald G. Decker, Dean of Colorado State College, Greeley, and Chairman of the NSTA Curriculum Committee; Paul DeH. Hurd, Professor of Education, Stanford University, Stanford, California; and Ole Sand, Director of the NEA Project on the Instructional Program of the Public Schools, Washington, D. C.

Presentations of a variety of science teaching and curriculum innovations will be given in a special series of panels. New for NSTA is a display of demonstrations and experiments originated by practicing teachers to be on exhibit throughout the convention. There will be a larger than ever Curriculum Materials Center under the chairmanship of Paul DeH. Hurd.

In conjunction with NSTA, the National Science Supervisors Association (NSSA), the Association for the Education of Teachers in Science (AETS), and the Business-Industry Section of NSTA will hold their annual meetings. Additional NSTA activities will include: a Youth Science Congress, an activity of the Future Scientists of America program; a special program for future science teachers, for college and university students; showings of films and audio-visual materials; and the annual Exposition of Science Teaching Materials. See "Program at a Glance" for further information.

"Science Teaching for the Learner"



NATIONAL SCIENCE TEACHERS ASSOCIATION
1201 Sixteenth Street, N.W. Washington, D.C.

GENERAL SESSIONS

First General Session:

Ralph W. Tyler, Executive Director of the Center for Advanced Study in the Behavioral Sciences, Stanford, California. Author and co-author of books relating to educational measurement and research. Saturday morning. Topic: "Forces Redirecting Science Teaching."

Second General Session:

Robert W. MacVicar, Professor of Biochemistry, Vice President in charge of Academic Affairs, and Dean of the Graduate School, Oklahoma State University, Stillwater. Saturday evening. Subject: "New Frontiers in Science."

Third General Session:

Evan R. Keislar, Associate Professor of Education, University of California, Los Angeles. Author and researcher in the social psychology of adolescents and school learning. Sunday afternoon. Address: "The Learning Process and the Teaching of Science."

Fourth General Session:

Emilio G. Segrè, Professor of Physics, University of California, Berkeley. Nobel Prize Laureate in 1959 for his contribution to the discovery of the antiproton; also co-discoverer of the first synthetic element, *technetium*. Sunday evening. Annual Banquet Address: "The Antiproton."

Fifth General Session:

This session, Monday morning, will feature a symposium on curriculum development. The three speakers at this symposium will be: *Donald G. Decker,* Dean of Colorado State College, Greeley, and Chairman of the NSTA Curriculum Committee; *Paul DeH. Hurd,* Professor of Education, Stanford University, Stanford, California, curriculum consultant, coordinator of the Shell Merit Fellowship Programs; and *Ole Sand,* Professor of Education on leave from Wayne State University, Detroit, Michigan, Director of the Project on the Instructional Program of the Public Schools for the National Education Association, Washington, D.C.

Sixth General Session:

"Resolutions, Recommendations, and Summary of the Members." This session, Tuesday afternoon, will be under the direction of *Hubert M. Evans,* Professor of Natural Sciences, Teachers College, Columbia University, New York City. Dr. Evans is the Chairman of the Committee on Resolutions of NSTA.

PANEL PRESENTATIONS

Panels will be headed by the following Chairmen in each respective area. Associated with the Panels for each of the five areas of concern is a representative from the convention Resolutions Committee:

Chairmen

Resolutions Committee

Curriculum. *Fletcher G. Watson,* Associate Professor, Graduate School of Education, Harvard University, Cambridge, Massachusetts. The panel will include discussion on such areas as biology, junior high school science, elementary science, and other related areas.

Curriculum. *Elizabeth Ann Quinn,* General Science Teacher and Assistant Principal, Saxe Junior High School, New Canaan, Connecticut.

Staffing. *Helen E. Hale,* Supervisor of Senior High School Science and Mathematics, Baltimore County Public Schools, Towson, Maryland. Elementary science, teacher assistants, certification, supervision, merit, and related areas will be covered.

Staffing. *Robert D. Binger,* Supervisor, State Department of Science Education, Tallahassee, Florida.

Programing. *Donald W. Stotler,* Supervisor of Science, Portland Public Schools, Portland, Oregon. Guidance will be offered concerning team teaching, scheduling, grouping, advanced placement, and other problems to be faced in improving the science program.

Programing. *Richard L. Miller,* Supervisor of Physical Science, Los Angeles Public Schools, Los Angeles, California.

Instructional Materials and Facilities. *Stanley E. Williamson,* Chairman, Department of Science Education, Director of Student Teaching, Oregon State University, Corvallis. The items to be covered include teaching machines, films, television, the NDEA, business-industry materials, laboratory facilities and equipment, and other teaching aids.

Instructional Materials and Facilities. *John H. Marean,* President-elect of NSTA, 1962-63; Science Teacher, Reno High School, Reno, Nevada.

Evaluation. *John M. Mason,* Professor of Education, Michigan State University, East Lansing. The approach in this area will be directed to techniques, studies in progress, subject matter, achievement tests, critical thinking, ability grouping, and programed teaching in education.

Evaluation. *Alexander Taffel,* Principal, Bronx High School of Science, New York City.

PROGRAM AT A GLANCE

FRIDAY, MARCH 9

8:00 a.m. Registration
9:00 a.m. **National Science Supervisors Association (NSSA), General Session:** *"The Dynamics of Supervision,"* Paul DeH. Hurd, Stanford University, Stanford, California; *"New Directions and Additions to Content and Their Implications for Supervision,"* J. Stanley Marshall, Florida State University, Tallahassee; *"New Directions in Science Teaching Methods,"* John W. Renner, University of Oklahoma, Norman
12:30 p.m. Supervisors' Luncheon. *"The Role of the School Administrator in Science Education,"* Robert Johnson, Unified School District, Palo Alto, California
2:00 p.m. NSSA Concurrent Panel Discussions
8:00 p.m. **NSSA Evening Session:** *"New Horizons in Science,"* Arthur Martin, Seattle University, Seattle, Washington

SATURDAY, MARCH 10

8:00 a.m. Registration
8:00 a.m. Exposition of Science Teaching Materials
8:00 a.m. Curriculum Materials Center
8:00 a.m. Film Showings
8:00 a.m. Display of Teacher-Devised Demonstrations
9:00 a.m. Business-Industry (B-I) Section All-Day Workshop
10:30 a.m. **NSTA First General Session:** *"Forces Redirecting Science Teaching,"* Ralph W. Tyler, Center for Advanced Study in the Behavioral Sciences, Stanford, California
12:00 noon Exposition of Science Teaching Materials
12:00 noon Curriculum Materials Center
12:00 noon Film Showings
12:00 noon Display of Teacher-Devised Demonstrations
12:30 p.m. Luncheon; co-sponsored by Elementary School Science Association (ESSA), Northern California. *Speaker,* Robert Karplus, University of California, Berkeley
12:30 p.m. Luncheon; co-sponsored by California Science Teachers Association (CSTA), Northern Section
3:00 p.m. NSTA Concurrent Sessions: *"Innovations in Science Teaching"*
7:30 p.m. **NSTA Second General Session:** *"New Frontiers in Science,"* Robert W. MacVicar, Oklahoma State University, Stillwater
9:00 p.m. Open NSTA Choral Session

SUNDAY, MARCH 11

8:30 a.m. NSTA Life Members' Breakfast
8:30 a.m. B-I Section Breakfast and Annual Meeting
9:00 a.m. **Association for the Education of Teachers in Science (AETS), Panel:** *"The Work of AETS,"* Fletcher G. Watson, *Moderator,* Harvard University, Cambridge, Massachusetts
10:00 a.m. Registration
10:00 a.m. Exposition of Science Teaching Materials
10:00 a.m. Curriculum Materials Center
10:00 a.m. Film Showings
10:00 a.m. Display of Teacher-Devised Demonstrations
10:00 a.m. B-I Section Workshop
10:00 a.m. NSSA Business Meeting
1:00 p.m. **NSTA Third General Session:** *"The Learning Process and the Teaching of Science,"* Evan R. Keislar, University of California, Los Angeles
3:00 p.m. NSTA Concurrent Symposia, I. Five Areas of Concern: Curriculum, Programing, Staffing, Instructional Materials and Facilities, Evaluation
7:30 p.m. **NSTA Annual Banquet (Fourth General Session):** *"The Antiproton,"* Emilio G. Segrè, University of California, Berkeley

MONDAY, MARCH 12

8:00 a.m. Registration
8:00 a.m. Exposition of Science Teaching Materials
8:00 a.m. Curriculum Materials Center
8:00 a.m. Film Showings
8:00 a.m. Display of Teacher-Devised Demonstrations
10:00 a.m. **NSTA Fifth General Session:** Symposium on Curriculum Development: Donald G. Decker, Colorado State College, Greeley; Paul DeH. Hurd, Stanford University, Stanford, California; and Ole Sand, Project on Instructional Program in the Public Schools, National Education Association, Washington, D. C.
12:30 p.m. Business-Industry-Education Luncheon: *"Science and Science Teaching for the Future,"* Howard G. Vesper, Standard Oil Company of California, San Francisco
3:00 p.m. NSTA Concurrent Discussion Groups
7:00 p.m. "A Night in Chinatown," tour and dinner

TUESDAY, MARCH 13

8:00 a.m. Registration
8:00 a.m. Exposition of Science Teaching Materials
9:00 a.m. NSTA Concurrent Symposia, II. Five Areas of Concern
11:00 a.m. Curriculum Materials Center
11:00 a.m. Film Showings
11:00 a.m. Display of Teacher-Devised Demonstrations
11:00 a.m. Future Science Teachers: Special Program
11:00 a.m. Future Scientists of America: Youth Science Congress
11:00 a.m. Tours
11:00 a.m. B-I Section Workshop
1:00 p.m. NSSA Consultant Services
3:00 p.m. **NSTA Sixth General Session:** *"Resolutions, Recommendations, Summary,"* Hubert M. Evans, Teachers College, Columbia University, New York City
7:30 p.m. AETS Annual Business Meeting

WEDNESDAY, MARCH 14

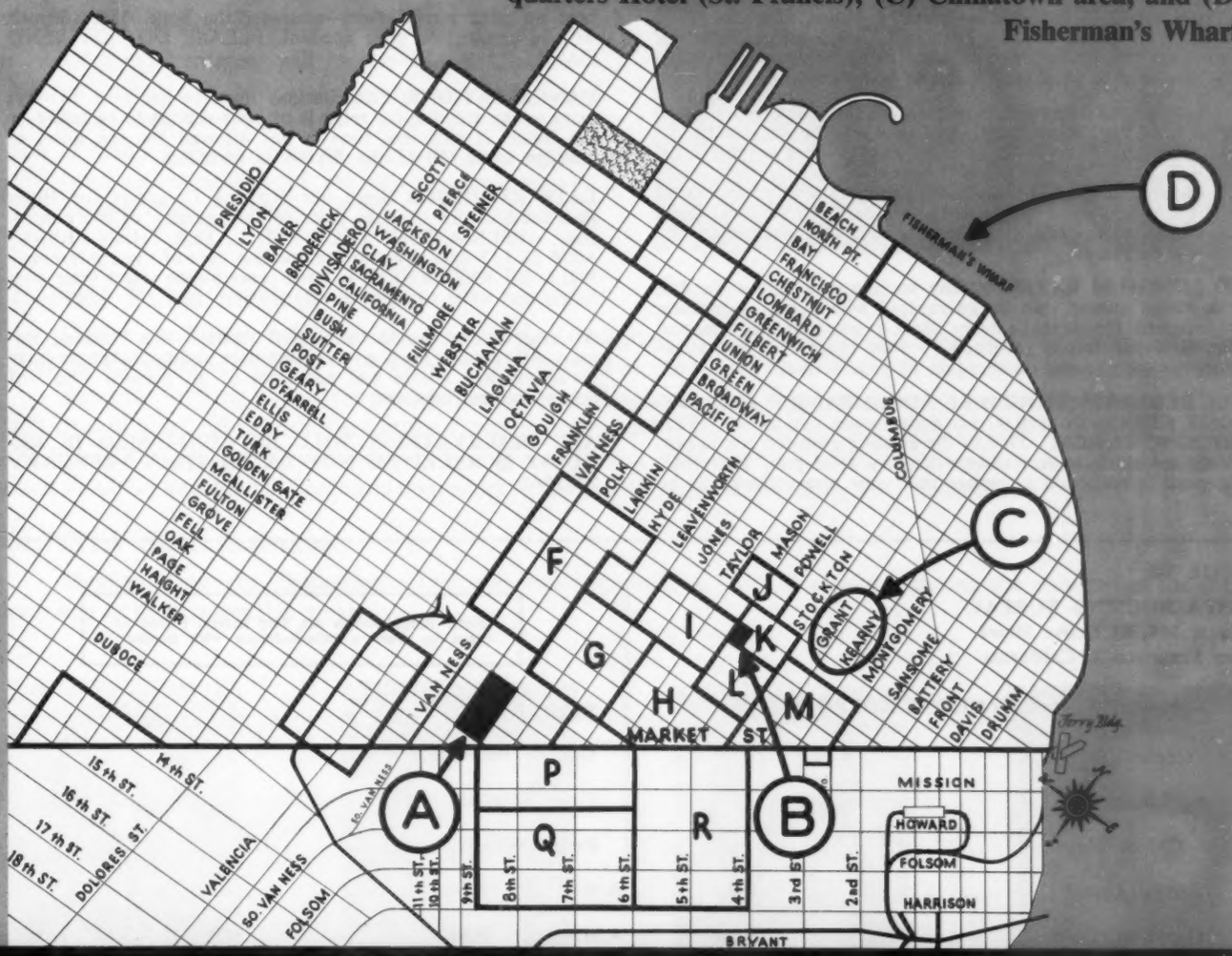
9:00 a.m. **AETS, General Session:** *"The Education of Elementary School Teachers in Science,"* Robert Stollberg, San Francisco State College, San Francisco, California
12:00 noon AETS Luncheon: *"The Task Before Us,"* Fletcher G. Watson, Harvard University, Cambridge, Massachusetts
2:30 p.m. AETS Symposium: *"Summer Institutes for the Improvement of Science Teaching,"* David S. Sarner, *Presiding,* Keene Teachers College, Keene, New Hampshire

Reservations are available from the following hotels and motels in San Francisco. Rates quoted are as of October 1, 1961, and may be subject to small variations. Please refer to zones on map for locations.

ZONE	HOTEL	SINGLE	DOUBLE	TW B
I	BELLEVUE, 505 Geary	$ 8 - $10	$11 - $14	$1
H	CALIFORNIAN, 405 Taylor	$ 8.50 - $10	$10.50 - $12	$1
K	CARTWRIGHT, 524 Sutter	$ 7	$ 9	$1
L	CHANCELLOR, 433 Powell	$ 7.50	$ 9.50	$1
H	CLIFT, Geary-Taylor	$14 - $23	$14 - $23	$1
P	DEL WEBBS TOWNEHOUSE, Eighth & Market	$14	$16	$1
H	DON, 345 Taylor	$ 5.50	$7	$
M	DRAKE WILTSHIRE, 340 Stockton	$10 - $11	$12 - $14	$1
I	EL CORTEZ, 550 Geary	$ 8 - $12	$10 - $14	$1
P	FEDERAL, 1087 Market	$ 5 - $5.50	$ 7 - $7.50	$
L	FIELDING, 386 Geary	$ 9 - $12	$11 - $13	$1
L	FRANCISCAN, 350 Geary	$ 7 - $8	$ 8 - $10	$
I	GAYLORD, 620 Jones	$ 8.50	$11	$1
H	GOLDEN STATE, 114 Powell	$ 6 - $7	$ 7.50 - $8.50	$
F	JACK TAR, Van Ness-Geary	$14 - $24	$14 - $24	$1
L	KING GEORGE, 334 Mason	$ 8	$10	$1
R	LANKERSHIM, 55 Fifth	$ 5.50 - $6	$ 7.50 - $8	$
G	LA SALLE, 225 Hyde	$ 6 - $7	$ 7 - $8	$
L	MANX, 225 Powell	$ 8 - $10	$10 - $11	$1
I	MAURICE, 761 Post	$ 7 - $10.50	$ 9 - $12.50	$1

SAN FRANCISCO

The major activities of the convention will be held at the Convention Center which consists of the civic auditorium, Brooks Hall, and related areas. This and other locations of interest noted are: (A) Convention Center (Press Office, Registration, Service Centers, and Exhibits), (B) Headquarters Hotel (St. Francis), (C) Chinatown area, and (D) Fisherman's Wharf.



UBLE	TWIN BEDS	PARLOR SUITE
4	$12 - $15	$20 - $30
- $12	$11 - $14	$22 - $25
	$10	
	$10.50	
3	$17 - $23	
	$18 - $22	$35 - $65
	$ 8.50	
4	$16	$35 - $45
4	$11 - $16	$22 - $28
.50	$ 8	
3	$12 - $15	$25 - $35
0	$ 9 - $12	$16 - $20
	$13	
$8.50	$ 8.50 - $10	
4	$16 - $24	$32 - $54
	$12	$25
$8	$ 8 - $9	
	$ 8 - $9	$16
	$11 - $12	$15 - $20
2.50	$10 - $13	$19.50 - $20

ZONE	HOTEL	SINGLE	DOUBLE	TWIN BEDS	PARLOR SUITE
H	NEW DALT, 34 Turk	$ 6 - $7.50	$ 9 - $10	$10 - $11	
H	OXFORD, 16 Turk	$ 7 - $8	$ 9 - $10	$10 - $11	
R	PICKWICK, 85 Fifth	$ 8	$10	$12	$20 - $26
L	PLAZA, 310 Post	$ 7.50 - $11.50	$ 9.50 - $14.50	$10.50 - $14.50	
L	ST. FRANCIS, Union Square	$12 - $24	$15 - $23	$17 - $27	$30 - $55
G	SENATE, 467 Turk	$ 5.50 - $6	$ 7 - $8	$ 9 - $10	
G	SENATOR, 519 Ellis	$ 5.50	$ 6.50	$ 7.50	
P	SHAW, 1112 Market	$ 5.50 - $6.50	$ 7.50 - $8.50	$ 9.50	$18
L	SIR FRANCIS DRAKE, 450 Powell	$12 - $17	$14 - $19	$18 - $22	$34 - $52
L	SPAULDING, 240 O'Farrell	$ 6 - $8	$ 7 - $9	$ 8 - $10	
L	STEWART, 351 Geary	$ 8 - $12	$10 - $14	$12 - $18	$28 - $35
L	STRATFORD, 242 Powell	$ 5 - $5.50	$ 7	$ 8 - $9	
P	WHITCOMB, 1231 Market	$ 7 - $12	$ 9 - $16	$10 - $18	$20 - $60
I	WORTH, 641 Post	$ 7	$ 8	$10	
G	YMCA HOTEL, 351 Turk	$ 4.75 - $5.50	$ 5.60 - $6.25	$ 7 - $7.50	
	MOTEL				
F	AUDITORIUM TRAVELODGE, 790 Ellis	$10 - $12	$12 - $13	$14 - $16	
F	CIVIC MANOR, 825 Polk	$10.50	$12.50	$15	
P	MART, 101 Ninth		$12	$14	$20 up
F	SAFARI, 860 Eddy	$ 8 - $10	$ 8.50 - $12.50	$12 - $16	$22 - $32

HOTEL RESERVATION FORM

TENTH NATIONAL CONVENTION

National Science Teachers Association, March 9-14, 1962

SAN FRANCISCO, CALIFORNIA

A HOUSING BUREAU has been organized for the 1962 NSTA Convention in San Francisco. Since all requests for rooms are handled in chronological order, it is recommended that you send in your application as quickly as possible.

In making hotel reservations, please use the blank below, indicating your first, second, and third choice of hotels (see list on reverse side). Because of the limited number of SINGLE ROOMS AVAILABLE, you will have a better choice of securing accommodations in the hotel you prefer if your request calls for rooms to be occupied by two or more persons. Rates quoted are for the room, and in case of double occupancy, the rate will be shared.

NO MINIMUM RATES, or any specific rate within the full price range quoted, can be guaranteed when your reservation is confirmed. Hotels make every effort to give you the requested rate. However, this is governed by prior check-outs and availability of such rooms on the date of your arrival.

ALL REQUESTS SHOULD BE ACCOMPANIED BY A DEPOSIT CHECK for $10.00 per room made out to the NSTA HOUSING BUREAU. Due to the existing crowded conditions, hotels cancel unclaimed reservations by 4:00 p.m. Therefore, a deposit is requested to ensure that your reservations will be held on your arrival date—whatever the hour. Your deposit will be credited to your account. PLEASE DO NOT SEND CASH.

CANCELLATIONS: Cancellations must be received 15 days prior to the meeting for refunds of your deposit to be made by the hotel. If sufficient time is not allowed for the hotel to reassign space, all of the deposit is forfeited.

LATE REQUESTS: Since our Housing Contracts for Hotel Bedrooms expire 15 days prior to the opening of the conference, APPLICATIONS RECEIVED LATER THAN FEBRUARY 23 (15 days prior to the opening date of the conference) WILL BE RETURNED. In such cases please select your own hotels and write to them direct.

All reservations should be cleared through this Housing Bureau. All requests must give definite date and approximate hour of arrival and names and addresses of all persons who will occupy rooms requested.

ALL RESERVATIONS WILL BE CONFIRMED IF REQUEST IS RECEIVED NOT LATER THAN FEBRUARY 23, 1962.

MAIL TO:

NSTA HOUSING BUREAU
Room 300, 61 Grove Street
San Francisco 2, California

PLEASE MAKE RESERVATIONS NOTED BELOW:

First Choice Hotel.....

Second Choice Hotel.....

Third Choice Hotel.....

(Note: Single rooms are very scarce. Please arrange to share a twin-bedroom with another.)

Single Room.....

Double Bedroom.....

Twin Bedroom.....

Parlor, bedroom suite.....

Arrival Date..... Hour..... A.M..... P.M.....

Departure Date..... Hour..... A.M..... P.M.....

NAMES OF ALL OCCUPANTS:
(Please bracket those sharing a room)

_____ _____

_____ _____

_____ _____

Check for $..... payable to NSTA HOUSING BUREAU is enclosed. Please send a self-addressed, stamped envelope.

NO HOTEL RESERVATION CONFIRMED WITHOUT THIS APPLICATION FORM

MAIL CONFIRMATION TO:

Name.....
(Please print or type)

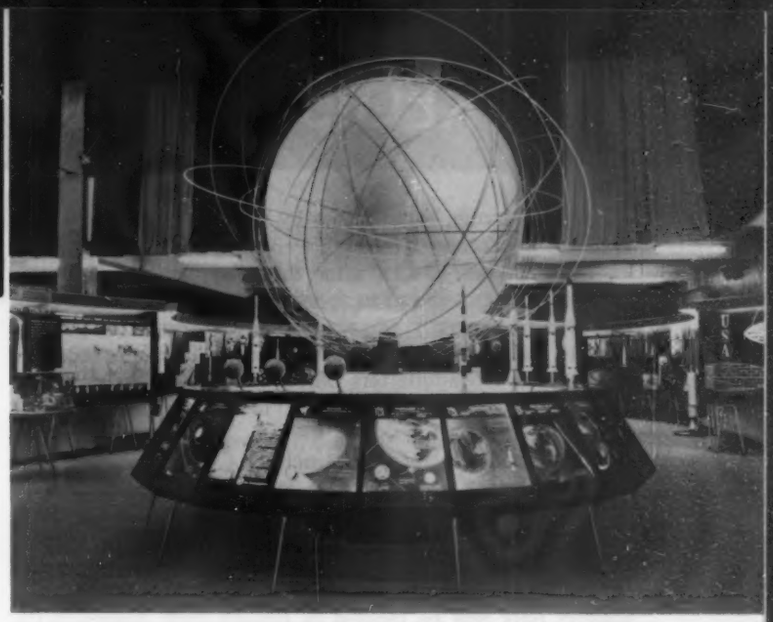
Company.....

Address.....

City.....

(Signed).....

FEATURES . . .



1. NASA Space Science Exhibit

Of special interest will be the World Globe exhibit of the U. S. National Aeronautics and Space Administration. This exhibit is a dramatic representation of man's quest in space to search for new knowledge and understanding of the world's environment. The World Globe exhibit will be located in Larkin Hall.

2. Press Room Services

Copies of all major addresses presented in the convention will be available, whenever possible, within 24 hours after the scheduled event. The Press Office will be located on the second floor of the Civic Auditorium, Room 200.

Advance working papers for the five major areas of concern have been prepared by the panel chairmen. These will be sent to all NSTA members in the January issue of the Packet Service. A limited number will be on hand at the Press Office during the convention. Careful reading and considered reflection on the problems and essentials of each should be regarded as "required homework" for everyone prior to attending the convention.

3. NSTA Staff Assistance

Members from the Headquarters Office in Washington, D. C. will be available during the convention for consultation in their respective areas.

Robert H. Carleton, *Executive Secretary,* Convention Headquarters Office, Brooks Hall,

Marilyn E. Suthard, *Secretary to Mr. Carleton,* Convention Headquarters Office, Brooks Hall.

George A. Crosby, *Business Manager,* Membership Services and Exposition, Brooks Hall.

Helen A. Brown, *Assistant Business Manager,* Membership Services and Publications, Brooks Hall.

Kent H. Godwin, *Administrative Assistant,* Registration area, Brooks Hall.

Dorothy T. Tryon, *Director, Future Scientists of America.*

Frank R. Salamon, *Specialist in Elementary Science; Editor, Elementary School Science Bulletin.*

Marjorie H. Gardner, *Director, Vistas of Science Program* and *Assistant Executive Secretary.*

Frances J. Laner, *Director of Publications; Editor, The Science Teacher;* Press Director, Room 200, Civic Auditorium.

REGISTRATION INFORMATION

Pre-convention registration by mail is strongly urged and will be accepted through February 16, 1962. **Do not mail forms and checks after this date,** since processing prior to the convention cannot then be assured. Receipts will be sent promptly when advance registration and reservations, accompanied by remittance in full, are received in the NSTA headquarters office. Present your receipts at the Advance Registration Table to receive identification badge and tickets.

All registration facilities, including Advance Registration and Ticket Sales, will be located on the Mezzanine of the St. Francis Hotel *only* on March 8 and 9. These facilities will be moved to Brooks Hall at the convention center on March 10 and will remain there for the duration of the convention. **Registration accommodations for exhibitors only will be located in Brooks Hall, March 9-13.**

Registration fee is $4 and is required for participation in all convention activities. Those registering in advance, but unable to attend the convention, may receive refunds by sending their official receipts to NSTA headquarters before April 6, 1962.

MEAL FUNCTIONS—In view of the large attendance expected at the convention, it would be to your advantage to make advance reservations for meal functions. Except for the Life Members' Breakfast, meal functions are open to all registrants. **Use form below and send remittance with registration fee.** You will receive your tickets when you pick up your credentials at the Advance Registration Table.

TOURS—Since the tours occur relatively late in the convention, there is no advance ticket sale. Tickets will be sold at the Registration Desk in Brooks Hall beginning Saturday, March 10. Some or all of the following tours will be available to convention participants on Tuesday, March 13, from 11:00 a.m. to 3:00 p.m.:

1. Radiation Laboratory, University of California, Berkeley: cyclotron, bevatron, and physics and chemistry laboratories.
2. U. S. Army Corps of Engineers, Sausalito: scale model of San Francisco Bay and river delta.
3. Stauffer Chemical Company, Richmond: contact process, sulfuric acid plant.
4. Field Experiment Station, University of California, Richmond: algae culture studies and ship models.
5. Cutter Laboratories: production of pharmaceutical chemicals.
6. Ames Laboratories, Moffett Naval Air Station: wind tunnel.
7. Foothill College, Los Altos: new junior college campus of unique architectural and educational design.
8. Westmore High School, Daly City: unique school architecture.
9. Visit to an elementary school with unusual science teaching facilities.
10. Gray Line tours will be available to many points of interest in the Bay Area including Muir Woods.

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California Science Teachers Association Luncheon (Sat)	.....	@ $4.50	.....
Life Members' Breakfast * (Sun)	.....	@ $3.50	.....
Annual Banquet (Sun)	.....	@ $6.00	.....

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	No. of Tickets		Total
Business-Industry-Education Luncheon (Mon)	.....	@ $4.50	.....
Night in Chinatown (Mon)	.....	@ $4.00	.....
Accompanying Tour	.....	@ $1.00	.....
Association for Education of Teachers in Science Luncheon (Wed)	.....	@ $4.50	.....
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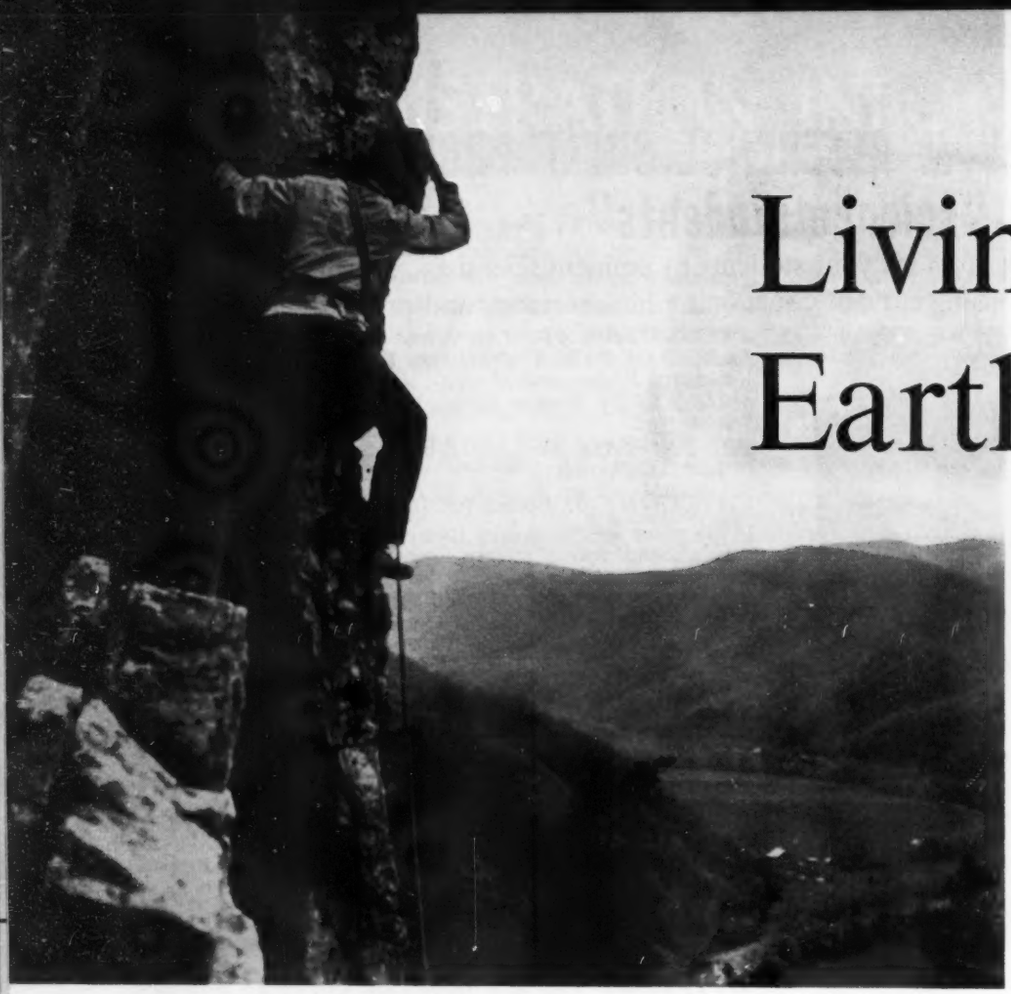


Living Earth Science

By IVAN L. JIRAK

Science Teacher, Knoxville Junior High School, Pittsburgh, Pennsylvania

STUDENTS sometimes find it difficult to understand earth science. One reason for this may be the rather obscure relationship that the earth has to everyday activities, such as walking on the ground, breathing in the air, or driving along the highway.

Unconformities, erosional stages, and diurnal differences, these things have no bearing on everyday living. The solidness of rock, the erosional force of water, and the tremendous pressures which shape Earth are better understood by experiencing some of the majesty of the place in which we live. First-hand experiences on a mountain or in a mysterious cave as contrasted to an account in a book have much more meaning for the student.

The areas having geological interest are pointed out to the students by the teacher.

At Knoxville Junior High School in Pittsburgh, an extensive field trip program has been in effect to introduce geology, biology, and related sciences to the students. A total of four school days and four vacation days are utilized to travel 2200 miles with the students and their parents to learn about earth science.

One of the most popular trips involves mountain climbing and cave exploring. We are fortunate in Pittsburgh in having both high rock outcroppings and beautiful caves that are close by. Seneca Rocks, West Virginia, is the location of the climbing-exploring classroom activity reported.

Mountaineering techniques are practiced on the play field with ropes a few feet from the ground. These take the place of ropes which will be used when climbing hundreds of feet high on some mountain later. The full itinerary of the trip is discussed in detail. Models of rock outcroppings and topography help students visualize the areas to be visted before the journey.

Parents drive with the students to the teaching areas. One adult mountain climber goes in each car. The twelve-car caravan stops frequently along the route to look at mines, folds and faults, saw mills, blast furnaces, and unconformities.

At Seneca seventy parents and students divide into two groups. One or two speleologists will take twenty-five students into a safe but noncommercial cave. The other group divides into "ropes" of one mountain climber and three students each.

In the cave, bats, cave spiders, and any other living organisms encountered are studied. Facts learned about rock formations are most amazing to those newly aware of functions in darkness, a new comprehension of the changing earth becomes apparent.

On the rocks, the braver students and the leaders try to climb 1200 feet to the top of Seneca Rocks. From that vantage point is seen the three stage erosional valley of the Potomac River. A few moments in the warm sun, a gentle breeze blowing, and sitting on top of a mountain, all these are sufficient to stimulate many children. Somehow a boy holding to a rock apprehensively

Students share the adventure of crossing the Potomac River by a swinging bridge.

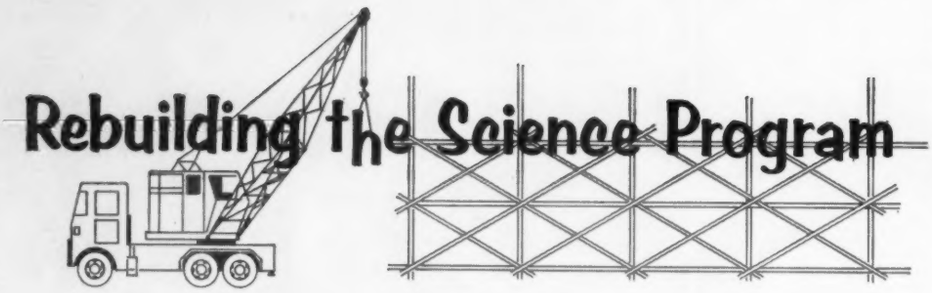
During cave investigations, students are amazed to learn of underground rock formations and how they develop.

learns more about rocks and the earth than one sitting in a classroom memorizing geologic ages and strange sounding names.

For the long trip back, a route with contrasting features enables us to take full advantage of the last 200 miles in the teaching program. Large waterfalls, limestone mines, and ancient blast furnaces vie for student attention. These experiences in living science last far beyond the school year and are often recalled with pleasure.

Mountaineering techniques are practiced in the school playground with ropes a few feet from the ground. Later, the student uses the rope to cross over a gorge.

Measurements are taken by students with a class-made clinometer.



Biology

Revitalize Your Biology Course

By MAITLAND P. SIMMONS

Science Teacher, Irvington High School, Irvington, New Jersey

TO broaden the horizons of a day-to-day biology course for the moderately gifted tenth-grade student,[1] the author offers a number of interesting and challenging science-learning possibilities to explore.

The first several weeks of school are spent primarily in orienting and updating academically-able students to present-day classroom materials. These essentials include advanced reference texts of their choosing, the recent Traveling High School Science Library at our school, the conventional basic text, and finally the ready-to-use standard laboratory equipment for the two double-class periods per week.

For the enrichment of this do-it-yourself course, students write three, two-thousand word papers, two which are of a library investigational nature, and a book reading of an approved selection. To sustain a high level of intellectual achievement, much time is used to discuss the special techniques for the writing of these scientific papers, such as carefully observing and recording data, developing an acceptable bibliographic method, budgeting time, and meeting a deadline. To instill some degree of exactitude and professional pride in their work, students are encouraged to submit attractive reports for the student bulletin board. Subsequently, each has to present his topic clearly, concisely, and strongly before the class. A high level of ease and proficiency in self-expression is a "must." No notes are allowed. Similarly, emphasis is placed on oral reporting procedures through knowledge of the literature relating to his own special well-chosen subject; thus, there is a direct tie-in between science and the English department which can be achieved in this manner. Subject-matter areas are essential to the total educational experience of the student.

A new field of endeavor for the young people with a potential creative originality and a deep-seated enduring interest in scientific research is opened for these students as they work on long-range science fair projects. A series of three-week progress papers on carefully selected problems in this area are then required. For new project ideas and factual information, students read extensively and intensively, exposing themselves to a variety of current scientific journals and periodicals, such as *Current Science and Aviation, Journal of Chemical Education, Science Digest, Science News Letter, Science World, Scientific American, The Scientific Monthly,* and *Turtox News.* To obtain other reliable data, students send letters to well-known professional scientists, and whenever possible, make personal

Joseph P. Cardillo was one of five Irvington High School students who demonstrated his prize-winning science fair project, "The Story of Reserpine," at a National Science Teachers Association convention.

CIBA PHARMACEUTICAL PRODUCTS, INC., SUMMIT, N.J.

[1] Maitland P. Simmons. "A Special Ability Group." *Bulletin of New Jersey Science Teachers Association,* 8:16-7. November 1959.

interviews. For those pupils of inquiring minds, who appear to be well under way in their chosen area, the writer will frequently visit their homes offering pertinent suggestions. Industry is another very valuable source as an aid in solving their experimental problems by loaning publications and supplying the necessary equipment.

The completed projects with their final "write-ups" are then entered into high-ability competition at the Greater Newark Science Fair sponsored by the Newark College of Engineering and at the Creative Chemistry Contest sponsored by the American Chemical Society or other competitions.

The exhaustively developed and scholarly manuscripts are also entered into a student award contest conducted by the Future Scientists of America of the National Science Teachers Association. Some of these young people have already participated in summer training advance research programs at various institutions of higher education.

HOFFMANN-LA ROCHE, INC., NUTLEY, N.J.

Stuart Rynone, Irvington High School, proudly displays his award-winning science fair project, "Flowers and Their Oxygen," at NJSTA conference in Atlantic City. His sponsor, Maitland P. Simmons (right) had charge of the exhibits and helped the students publicize their interests.

From this time-consuming undertaking of systematic procedure in gathering, appraising, interpreting, organizing, experimenting, and evaluating data; a method of critical and logical thinking develops. The role of doubting comes into being, the opposite to rote learning. It involves the use of facts, but only as an academic tool to begin arriving at understanding rather than as ends in themselves.

Follow Up

To insure a favorable intellectual climate, this kind of carefully organized thinking should be sufficiently developed and motivated within the total school curriculum. In other words, the avenue of solution in the scientific approach should rest upon the previous program of the student as he moves from one grade to another. The cooperative studies one is motivated to undertake depend largely upon his degree of interest, and these grow out of his earliest experiences. Research is a habit that ought not to be lost. It is a habit that forces the asking of intriguing questions and the seeking of activities in everyday living.

For this fast-moving class, other rewarding activities include a life-science debate on some biological topic structured by a student planning committee; for example, Resolved: The grasshopper is more destructive than the Japanese beetle to plant life in the United States. Pupils present mimeographed programs, debate the topic vigorously and effectively, and then listen intently to their recorded speeches. A follow-up period of well-worded questions provokes a lively discussion among this peer group. Some of the faculty graciously act as judges. From another learning experience, one student established a record of over 1300 listed insect names with damages and controls. Also a bird model contest affords much interest. Book publishers donate book prizes. An interesting do-it-home investigation includes the planting of a grape-fruit seed at a particular time of day. The prolonged study consists of recordings of compactness and type of soils including alkalinity and acidity, preparation of seed, depth of planting seed, amounts of water used, day-and-night temperatures of air and soil, variations of humidity, air currents, exposure and intensity of sunlight including artificial light, kinds and amounts of plant food, and stimulants used.

The first breakthrough is noted and later individual progress is seen when a project is brought to class for further development and study. From the daily quantitative data listed in their log books, students draw conclusions as to the desirable effects of the various factors affecting the rate of plant growth. Our young people must be able to make, read, and interpret measurements, and then draw conclusions from these findings. The quantitative approach characterizes much of the new high school program now being developed by the Biological Sciences Curriculum Study of the American Institute of Biological Sciences.

In terms of content, stress is placed on broad, basic concepts and the development of important principles of functional understanding of biology.

For depth of treatment and modernization of the subject, such vital facets as the role of vitamins, marine biology, conservation, microbiology, comparative anatomy, photosynthesis, viruses, and hormones are emphasized. Also specialized areas of biologistics, taxicology, radiation, physiological stress, and psychology are discussed and library research on space is required.

Records

A notebook is a "must" for carefully taking notes and listing a science vocabulary with considerable attention given to spelling of the basic and more widely working words. Emphasis is placed on word analysis, basic prefixes, and suffixes. Words are taught in a meaningful context. However, even more time is devoted to word analysis and the painstaking writing of words for the under-achievers. For an after-

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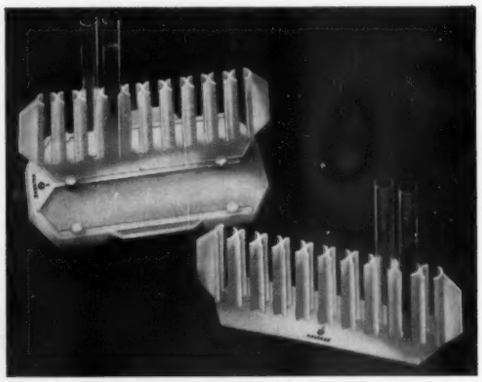

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school term project, this group builds a dictionary of the more common science terms with brief definitions.

In order to intensify a still deeper interest and depth of understanding of present concepts, our modern biology is channeled on numerous occasions into new and related areas, such as antibiotics and chemotheraphy. To help them obtain a better knowledge in expanding fields of this sort, all students in this group participate actively in a visit [2] to some pharmaceutical house.

From this out-of-class experience, they discover the range of observational skills and insight into scientific knowledge which are thereby enhanced. Students develop a sense of accomplishment from their creative booklets as a result of their meticulous observations. Escorted trips should afford intellectual satisfaction from this intimate relationship with their environment. Teachers must take science teaching out of the textbook, beyond the classroom walls, and into real life, if worthwhile understanding is to be developed.

IRVINGTON HERALD, IRVINGTON, N.J.

David V. Hunt, Irvington High School, proudly displays his Greater Newark Science Fair grand-award project, "Applications of Short Ultraviolet Radiation," at the National Science Fair in Flint, Michigan.

Experimental Work

A high level of academic performance in a specialized skill results when the biology class is up-graded by a set of appropriate open-ended investigations in which the students utilize new techniques, develop their own format, and record their own observations and findings. Through this procedure the teacher is able to give more individual attention to the students as they are working at their own rate. The planned experimental studies end for the year with the students presenting frog-skeleton mounts and bound copies of their detailed laboratory activities to the teacher for classroom display.

Since all formal sheets of the fill-in type are eliminated, these students of scientific bent have the opportunity to develop their own creativity. This they truly enjoy. Too much uniformity with massive doses of facts, so called spoon-fed-teaching, is most deadening.

For continued diversity, every morning for two months from 6:30 to 7:00 a.m., students look at a TV-modern chemistry program, "Continental Classroom," a college course given by a superior teacher, or whatever is scheduled in the science areas. They listen, take notes, and list important factual statements concerning the content of the program for that day. The up-to-date material is then compiled neatly in an attractive booklet and posted on the classroom bulletin board. It is hoped that this will lay a foundation for chemistry and will show the relationship of chemistry to biology.

Another significant television program included "The Thread of Life," an informative story of genetics. After viewing the one-hour evening show, students presented interesting excerpts from their prepared fifteen hundred-word papers. Attention is given to such major topics as process of fertilization, the work of Gregor Mendel, functions of chromosomes and genes, and the DNA. For an excellent review, the class had the opportunity to view a film in color. The purpose of the home-school lesson is to make this all-popular, but rather difficult subject understandable through the showing of animated drawings and "live" demonstrations that are available.

Throughout the entire year students constantly are encouraged to perform before visiting industrial scientists and qualified teachers from other schools. For example, one student made his own atomic model [3] and explained to the class and representative of the Westinghouse Corporation the effects of radiation on the human body.

Career Guidance

Those promising students who desire to enter teaching as a satisfactory career sign a student-teacher list. A selection of ten, five a term, is then made for the year. Each student reports one day a week for an hour after school. Under the supervision of the teacher, they examine notebooks of other classes as to topical outline, grammer, word spelling, correct content, and general overall neatness. Various written reports are also scrutinized and tests are keyed. A word of praise is noted on each worthy piece of work.

These prospective students feel it is an honor to have their names appear on the posted list. Furthermore, they see their grades improve by constantly reviewing the content.

[2] Maitland P. Simmons. "Planning and Conducting Industrial Tours for Science Classes." *For Better Teaching*. Bulletin No. 14. Department of School Services and Publications, Wesleyan University, Middletown, Connecticut.

[3] *The Westinghouse News*. August 1960. p. 7.

In regard to the current social climate, leadership is being recognized throughout the year. For example, at open house night, a student committee takes care of the parents by having them sign the guest book, escorting them to seats, and introducing them to the teacher. This proves to be a very efficient and pleasant way of meeting a larger number of parents. In like manner, appointed students throughout the year take care of all classroom visitors, carrying out the important assignment of explaining the lesson to the guests, while also improving social graces.

In the light of the rapidly changing knowledge of biology and the increased emphasis on competent research, the content and techniques employed should be evaluated carefully and continuously in terms of the contribution which they seem to make to the improvement of the education of all young people that have career interest.

• • • *Rebuilding the Science Program* • • •

General

Program Development in Unified Science

By IRWIN L. SLESNICK and VICTOR SHOWALTER

Science Teachers, The Ohio State University, Columbus, Ohio

THE teaching of secondary school science has rested upon a content organization of physics, chemistry, and life science for as long as science has been a part of the high school curriculum. The time seems at hand for the secure and sacred science disciplines to merge in depth by design. The results of such mergers will be courses of study that dissolve the partitions which have unnecessarily departmentalized unifying science concepts.

During the past few years specialists in physics, chemistry, and biology, in separate convocations, have identified the solid core of their respective disciplines and have adapted these bodies of knowledge and experience for the high school student. Currently, however, the established discipline organization of science is being challenged. Matter, energy, and life are not discrete studies for either the specialist or the generalist. The structure of science has long been recognized as a rapidly converging compendium which increasingly promises to fuse into unified concepts of the universe. In fact the ultimate goal of science is to produce a single theory on a cosmic scale to account for all phenomena. The major concepts of science are incompletely understood unless studied within the context of their interrelatedness.

Biological concepts are chemical, physical, geological, and psychological. The laws of thermodynamics permeate the content cores of the Chemical Bond Approach, the Biological Sciences Curriculum Study, and the Physical Science Study Curriculum materials. The traditional sciences exhibit many similarities in process. The construction of models, either physical or mathematical, is the creative heart of all science. The nature of science is interdisciplinary.

Prior to the appearance of the *Thirty-first Yearbook of the National Society for the Study of Education* (Part I, 1932) much had been written about the spiraling development of concepts from lower grades to higher grades. In some instances a spiraling core of concepts has been explicated and applied. Certain school systems can display in syllabi and classrooms, vertical threads of concept continuity. Fewer schools can demonstrate horizontal structures which fuse merging concepts. The most notably successful precedent of science integration during the past century has been the union of botany and zoology to form biology. Physics and chemistry have been united on occasion only to lose acceptance through the prestige pressures of the established disciplines. Originally, the efforts of the Physical Science Study Committee were aimed toward a two-year sequence of fused chemistry and physics. Consensus regarding the cause of the rapid extinction of general science is that it never had an internal coherence, having been only a hodgepodge of unrelated facts pilfered from the different kinds of science. An examination of general science textbooks reveals that they are largely a collection of preview studies of the differential sciences.

To propose that the out-dated boundaries between the science disciplines be dissolved in a modern curriculum is no longer visionary. The spiraling concepts of science which dangle vertically must now be crosswoven by a horizontal organization that gives unity, strength, and respectability to a curriculum. Teachers with a desire to work on the frontiers of science education might consider program development through a unified approach to the teaching of science.

The Program

One program now under way began in 1959 at the Center for School Experimentation at the Ohio State University. An integrated-fusion high school science curriculum (grades 9-12) is being developed and tested by the staff of the Ohio State University School. Educators and scientists in the role of consultants lend a national scope to the project. The project attempts in a four-year sequential program to fuse the subject matter and method of the formerly independent high school studies of life, matter, and energy into a unity of relationships. The first two years of the sequence, Science I and Science II have been incorporated into the University School program and are required of all ninth and tenth graders, respectively. During the 1961-62 school year, elective Science III was initiated and the following year the more specialized Science IV will begin. Each year a traditional science course is being replaced. The advantage of this curriculum reorganization can only be predicted. Evaluative measurement must await further refinement. Yet, it is believed that the content coverage of the four-year sequence should even-

tually exceed traditional coverage since duplication and overlap will be avoided. Moreover, all secondary school students should experience depth and breadth in studies involving matter, energy, and life. In the past, only the "science major" experienced such depth and breadth. The unique outcome of this horizontal organization, however, is that student exposure to science becomes a single, dynamic, orderly, understandable, controllable structure—not an archipelago of diverging or static islandic disciplines.

Organization

The structure of Science I is founded upon the interrelatedness of matter, energy, and life. Students inductively and deductively discover that chemical elements, forms of electromagnetic radiation, and species of plants and animals can be naturally classified on the bases of distinguishing properties, and, subsequently, ordered into periodic tables, spectra of electromagnetic radiation, and phylogenetic trees.

The student with a minimum of facts discovers theoretical schemes that reduce the array of endless diversity in the universe to a unity of relationships.

Having grasped the idea of orderliness of the universe in terms of component entities, students are ready to deal with concepts that interpret natural phenomenon in broad terms. There are certain fundamental generalizations of nature to which the student is naturally led. The laws of transformation of matter and energy set the pattern for the subsequent study of the sun. Elements of the sun undergoing nuclear changes release energy that literally controls the earth. Photosynthesis and weather are studied as two processes wherein a planet reacts to a star or other planetary objects.

Science II has also been freed from restrictive discipline boundaries. The depth teaching of the facts and mechanism of geologic and organic change are concurrent. The teaching of oxidation (reaction chemistry) fuses with respiration (biology), as do studies of nerve physiology with electrochemistry.

In the latter unit for example, students begin with a study of the case history, *Frogs and Batteries*. Here they experience the discoveries of early physicists, biologists, and chemists as they seek the sources of "animal electricity." On the modern scene they continue to see that nerve physiology is a correlation of depth physics and chemistry in the site of an organism.

The content of Science III is being organized in three principal and sequential units. Each of the units is integrated (*i.e.*, fused) by a single theme that is common to the structure of all science. Each theme reflects the dynamic nature of science and its processes.

Specifically, the three themes in order of presentation are: (1) Quantification, the foundation of science; (2) Human Senses, the way to science; and (3) Models, the expression of science.

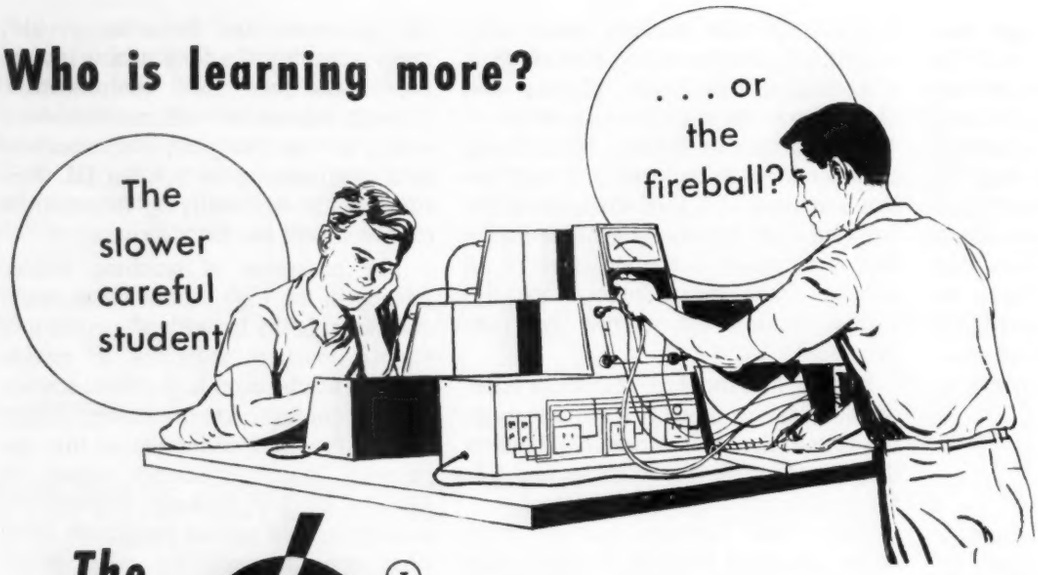
Each unit borrows heavily from other organized attempts to modernize the science curriculum. For example, kinematics as developed by the Physical Science Study Committee is an integral part of the larger unit on quantification. Electron configuration of atoms and the geometrical results of bonding with other atoms as developed by the Chemical Bond Approach fill a major portion of the unit on models. Biological processes and behavior provide many opportunities for students inventing techniques of quantification. Though Science IV will not become a reality for another year, it is conceived as a continuation of Science III. Presumably the first unifying theme to be exploited will be, Equilibrium.

The prospects of teaching unified science in the high school raises many questions. Is the breadth preparation of science teachers sufficient to enable them to teach secondary school science in fused context? Are the current school science facilities adaptable to this approach? Is unified science suited for just one kind of student? Who should develop unified science programs, using what concepts and for what grade levels?

Small pilot programs in unified science are known to be under way in several states. Their impact upon the current horizontal and vertical organization of school science will likely be felt, as more schools endeavor to adjust their curricula to the natural integrality of science.

Cubical Model of authors' concept of teaching unified science.

Who is learning more?



Of course, the best work is done by each student at his own speed. The rapid worker should be allowed to progress as rapidly as he can assimilate the material and the slower, more meticulous student should not be forced to work beyond his most efficient rate of learning.

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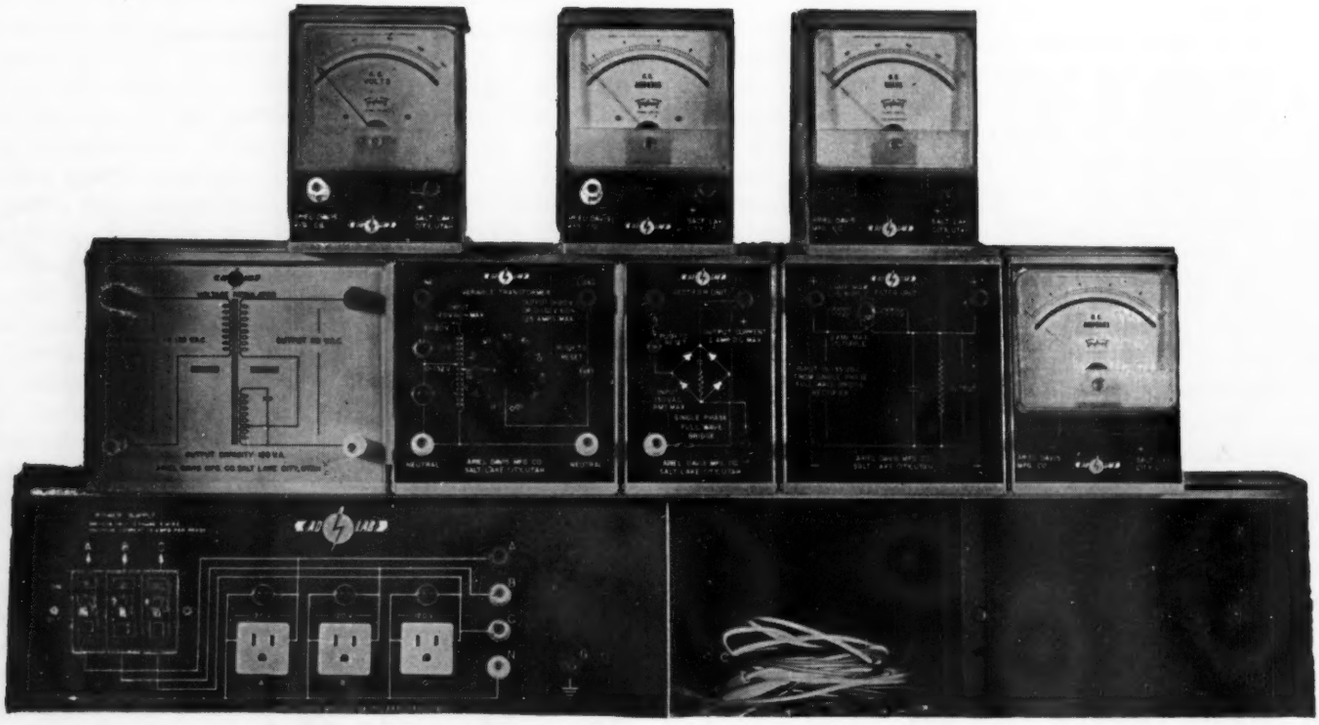

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Classroom IDEAS

Chemistry

Teaching Half Life Concepts

By LESLIE W. TROWBRIDGE, University of Michigan, Ann Arbor, Michigan

The concepts of half life for radioactive disintegration can be taught in a two-step process employing several graduated cylinders and water that contains vegetable coloring for better visibility.

In step one, a 1000-ml graduate is filled with colored water to the 1000-ml mark and a siphon hose is inserted to which a screw clamp is attached. The discharging end of the hose is placed in a second 1000-ml graduate as shown in Figure 1.

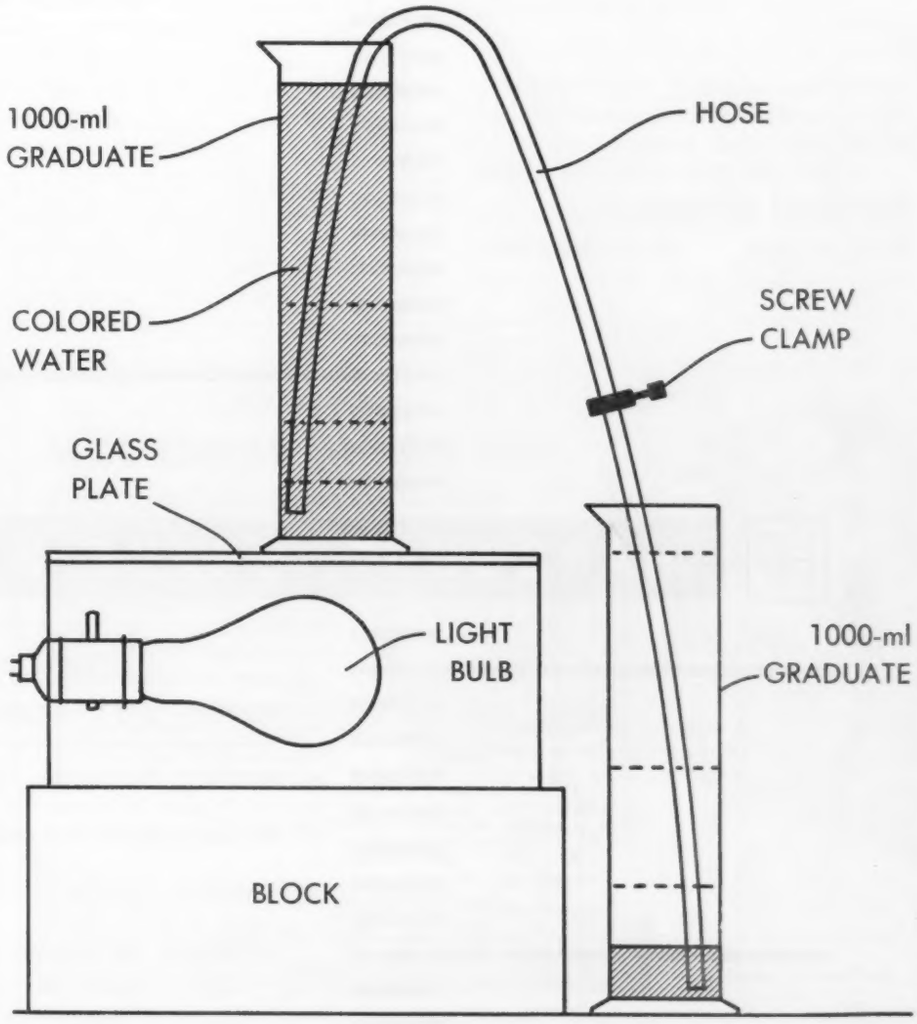
With this setup, the teacher may set the rate of discharge at some convenient level, explaining that the "half life" is perhaps one minute for this particular "radioisotope." Students will observe that at the end of the first minute, the level of the colored water in the first graduate is at the 500-ml mark, and at the end of the second minute, the level is at the 250-ml mark, etc.

Two things emerge from this: (1) that the rate at which water is leaving the graduate is decreasing (because of the decreasing flow as the levels in the two graduates approach each other); somewhat analogous to the decreasing rate of disintegrations in a radioactive substance as less of the parent element remains, and (2) that the discharged water caught in the second graduate may represent the residue after radioactive disintegration had taken place. Thus, by knowing the proportion of "residue" to "parent element" and the half life, it is possible to determine the original amount of the sample and its "age," or in other words the amount of time that has elapsed since the first graduate was filled to the 1000-ml mark. For example, if after a certain elapsed time the first graduate contains 125 ml and the second graduate contains 875 ml, and the "half life" is one minute, the original amount of the sample must have been 1000 ml, and its "age" must be three minutes (original amount $= 125 \times 3^3$).

In step two, a series of six 100-ml graduates are filled with colored water in the following amounts: 100 ml, 50 ml, 25 ml, 12.5 ml, 6.25 ml, and 3.125 ml, respectively. These six graduates are then set on top of the light box as shown in Figure 2.

When set up this way, the graduates represent the proportional amounts of the parent element remaining at the end of each successive half-life period. In addition, it can be seen that the surfaces of the liquid in successive graduates conform to an exponential curve. Thus it is possible at this point to have the students plot this curve by placing a stiff white cardboard directly behind the graduates. The cardboard should

FIGURE 1. Setup for showing amounts of "parent element" and "residue" remaining after successive half-life periods.



Which way

to biology?

Harcourt, Brace & World publishes two high school biology texts: *Exploring Biology, The Science of Living Things,* by Ella Thea Smith, and *Your Biology, Second Edition,* by Ella Thea Smith and Lorenzo Lisonbee. The first text is intended for the average and the better-than-average student; the second is for the "science-shy" student, the student who has reading problems, the student who takes more time to learn than the average.

Your Biology uses a nonacademic approach, uses textbook techniques that are appropriate to the special needs of the science-shy student. Reading lessons are short, student activities are varied and appear on almost every page, and explanatory illustrations are used profusely throughout the text. The writing is unusually clear and direct, with the reading level averaging about 8th grade.

The Second Edition of *Your Biology,* which has just been published, contains several new features which are sure to prove successful, among them a specially prepared, 16-page, full-color section of human body charts with "How It Works" diagrams on the page facing each chart, and a 256-page Teacher's Manual with many valuable, specific teaching suggestions.

If you are not familiar with the *Your Biology* approach to the science-shy student, we invite your inquiries.

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have the abscissa and ordinate drawn upon it and spacings on the abscissa marked off to correspond with the width of the bases of the graduates. These spacings likewise correspond to half-life periods. To plot the points, have a student sight the cardboard at the level of the water in each graduate and place a mark upon the cardboard in bright wax pencil. Removing the cardboard, a smooth curve can be fitted to these points.

Use of this device enables students to get a clearer conception of (a) the meaning of half life, (b) the use of half life in determinations of the age of radioactive samples, and (c) the meaning of the exponential decay curve by means of a direct visualization.

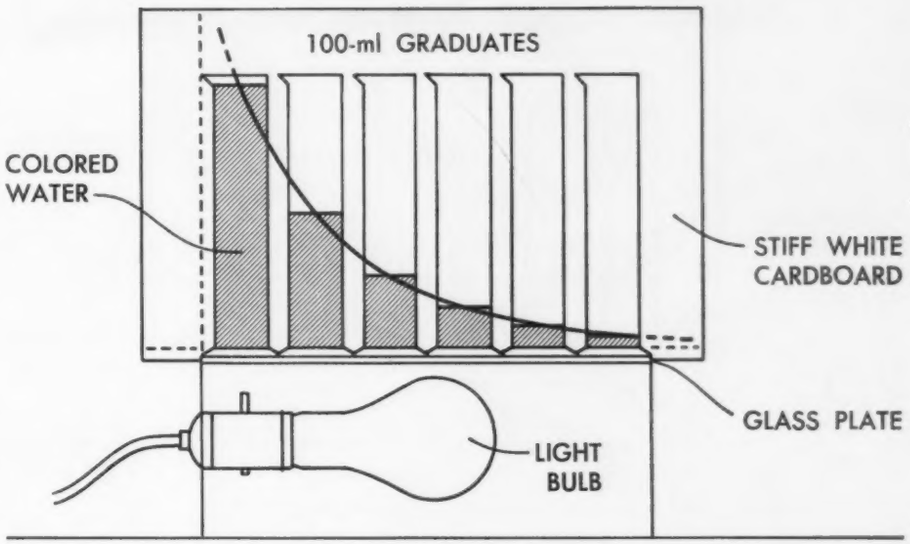

FIGURE 2. Setup used for plotting the exponential "decay curve" from direct visualization.

Chemistry

Solubility of Ammonia Gas

By ARCOT VISWANATHAN, The New College, Madras, India

A new method for demonstrating the solubility of gaseous ammonia has been used in the first year classes of our school. It may be of interest to other teachers.

Materials Needed:

1. Two clean dry gas collection jars (diameter, 6 cm; height, 20 cm) with ground-glass edges.
2. Water.
3. A colored cartesian diver with its density adjusted to be slightly higher than that of water. (Determine by experimentation.)
4. A source of dry gaseous ammonia, hydrogen chloride, carbon dioxide, and sulfur dioxide.

Procedure:

Half fill one of the gas collection jars with water and insert the adjusted diver previously mentioned. The open ground-glass seam of the jars should be well greased to facilitate a tight seal when the two are joined at the open end. Invert the second jar filled with ammonia gas over the first, pressing the two tightly together. If the diver has the proper density adjustment, it will slowly rise to the surface as the gas dissolves in the water producing a partial vacuum in the upper portion of the apparatus. After a short period, break the seal and slide the upper jar across the lower allowing air to re-enter the system. As the air enters, the diver will sink. Close the system, remake the seal, and the diver will rise, providing there is a sufficient quantity of ammonia gas remaining in the upper jar to reduce surface pressure. The demonstration may be repeated with other gases that exhibit the same physical properties as ammonia, but to insure best results the diver should be removed from the system and washed, the system cleaned, and fresh water added. This demonstration is another version of the classical "Fountain" experiment to determine the high solubility of ammonia gas.

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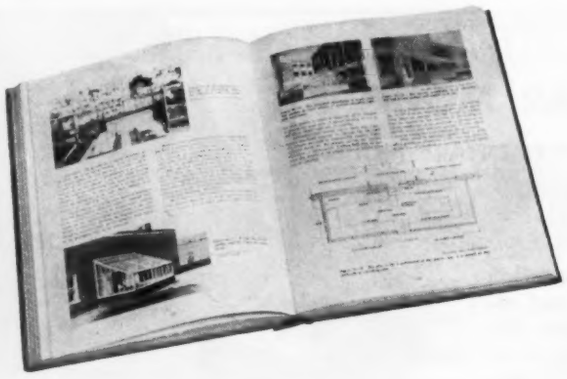
■ Nearly five hundred people contributed to the preparation of this book, including school superintendents and principals, elementary teachers and high school science teachers, school architects, science educators, and members of school boards and state departments of education.



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Staff Changes

John W. Renner leaves NSTA this month to accept appointment as Associate Professor of Education at the University of Oklahoma, Norman, beginning January 1, 1962. In his new position, Dr. Renner will head up a growing program of teacher education in science. He will work directly with the College of Education Dean, James G. Harlow, who is widely known in NSTA circles also. Dr. Renner joined the NSTA headquarters staff as Associate Executive Secretary in August, 1959.

Beginning January 1, 1962, Marjorie Gardner will serve as Assistant Executive Secretary of NSTA. In addition to her duties as Director of the Vistas of Science books program, Dr. Gardner's expanded responsibilities will include certain special projects and Association activities, some of which will be on an interim basis pending the appointment of a successor to fill the position vacated by Dr. Renner.

Membership Report

Each month, over 20,000 members and subscribers receive NSTA services which include *The Science Teacher,* the *Elementary School Science Bulletin,* the Packet Service, and special mailings. These services afford excellent opportunities for communication with teachers and supervisors on up-to-date curriculum developments, scientific reports, and progress reports of NSTA activities. The key to being fully informed in the field of science teaching is continuing membership participation in NSTA.

Do Not Let Your Membership Lapse. Membership renewal notices are sent to all sustaining, regular, and student members three or four months prior to expiration of services. You can facilitate the operation of membership maintenance by paying your renewal fee promptly. If you also hold membership in one of the Sections of NSTA, payment of such membership fee should be made *with* the NSTA payment that you send in.

Each One Invite One

Several weeks ago each of you received a letter from Madeleine Skirven, National Membership Chairman, encouraging you to invite one of your fellow teachers to join in membership in NSTA. We hope you made good use of the enclosed Membership Application Form and signed up a new member.

And now you have the opportunity to enroll another member. For your convenience a card has been bound into this issue of *The Science Teacher.* Detach and extend your personal invitation today. (Turn to page 69.)

New Membership Service

As an added service, regular and student members will receive a copy of the *Elementary School Science Bulletin* each month beginning with the January issue. *ESSB* is published by the Association eight times during the school year.

NSTA has initiated this service in response to numerous requests from secondary school science teachers and curriculum committees for materials concerning elementary school science. The Association is certain that through *ESSB,* more secondary school personnel will be able to keep informed of current trends and new developments in the elementary school science program.

Vistas of Science

Spacecraft, the first book of the Vistas of Science series of resource books for secondary school science, has just been released.

Contents include up-to-date developments on space vehicles and their uses. There is an activities section with projects for students to help them gain insights into spacecraft design and space travel. To clarify the text, both sections are abundantly illustrated with diagrams, charts, and photographs. The main text of *Spacecraft* was written by James J. Haggerty, Jr., science writer and consultant of Aerospace Industries Association of America, Inc., Washington, D. C. The activities section was prepared by John H. Woodburn, chemistry teacher at the Walter Johnson High School in Rockville, Maryland.

Spacecraft was produced as a cooperative endeavor of NSTA and the sponsor, the National Aeronautics and Space Administration, Washington, D. C. NASA evaluated the book's content for scientific and technical accuracy. NSTA coordinated the development of the manuscript and provided the advisory group and panel of science educators to determine the book's educational acceptability. The design and editing were done by the publisher, Scholastic Book Services, Inc., of New York City.

A copy of *Spacecraft,* as well as forthcoming books in the Vistas series, will

---

As a regular feature of *The Science Teacher,* the calendar will list meetings or events of interest to science teachers which are national or regional in scope. Send your dates to *TST*'s calendar editor as early as possible.

December 26-30, 1961: NSTA Annual Winter Meeting in conjunction with 128th meeting of the American Association for the Advancement of Science, Denver, Colorado

January 22-26, 1962: Annual Meeting, American Meteorological Society, New York City

January 24-27, 1962: Annual Meeting, American Association of Physics Teachers, Statler-Hilton Hotel, New York City (Joint meeting with the American Physical Society)

February 21-24, 1962: 35th Annual Meeting, National Association for Research in Science Teaching, Willard Hotel, Washington, D. C.

March 9-14, 1962: NSTA Tenth Annual National Convention, San Francisco, California

April 8-14, 1962: National Library Week

April 15-18, 1962: 40th Annual Convention, National Council of Teachers of Mathematics, Jack Tar Hotel, San Francisco, California

April 24-27, 1962: 59th Annual Meeting, National Catholic Education Association, Cobo Hall, Detroit, Michigan

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Another Vistas book scheduled soon for publication will relate to measurements, under the sponsorship of the National Bureau of Standards, Washington, D. C. The book has been written by William J. Youden, Sr., of the NBS Division of Applied Mathematics.

FSAA Regional Chairmen

The eleven regional chairmen for the 1961-62 Future Scientists of America Awards program have been appointed and are now preparing for action. They are now assembling judges who will evaluate 6000 or more reports of student projects which will be entered in this competition. The work of the chairmen and their committees in judging and evaluating entries is an important task and fully appreciated by NSTA.

Chairmen who have taken on the responsibility this year are as follows: Region I, Edgar N. Johnson, West Springfield High School, West Springfield, Massachusetts; Region II-A, Grace Murray, Monroe High School, Rochester, New York; Region II-B, A. M. Weckstein, Bridgewater-Raritan High School, Raritan, New Jersey; Region III, Paul Hounshell, Winston-Salem City Schools, Winston-Salem, North Carolina; Region IV, J. Stanley Marshall, Florida State University, Tallahassee; Region V-A, James Barnes, Eastern Michigan University, Ypsilanti; Region V-B, Wayne Kincaid, Manual Training High School, Indianapolis, Indiana; Region VI, Robert Yager, University High School, Iowa City, Iowa; Region VII, Barbara Van Hook, Lee's Summit Senior High School, Lee's Summit, Missouri; Region VIII-A, Harold Trautman, Portland Public Schools, Portland, Oregon; Region VIII-B, Harry K. Wong, Menlo-Atherton High School, Atherton, California.

All entries should be mailed as far in advance of the March 31, 1962 deadline as possible. This will assist the chairmen and their committees to complete selections of winning projects in time for all student awards to be presented by June 1, 1962. If you have not already done so, write to NSTA headquarters for entry forms and materials. Please limit your requests to cover 10 to 15 per cent of your total students.

Century 21 Exposition

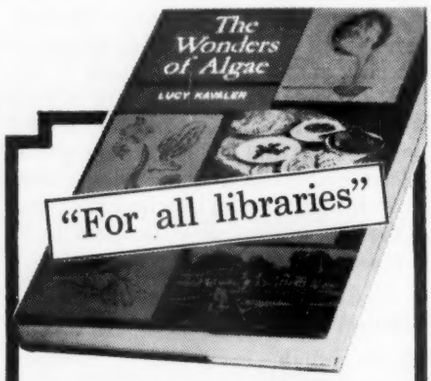
Robert A. Rice, NSTA Retiring President and Coordinator of the Children's Area Science Exhibit of the 1962 Century 21 Exposition in Seattle, has returned to Berkeley, California to assume a new position as Mathematics and Science Supervisor of the Berkeley public schools.

Through the services of Mr. Rice and an advisory committee, the Children's Area exhibits have been designed and are now under construction. They will be a part of the U.S. Science Exposition sponsored by the Department of Commerce. NSTA and Mr. Rice, however, will no longer be associated with the project as the contract between NSTA and the Government has been cancelled.

Teacher Science Study Tour, 1962

Prospects for NSTA's Second European Science Study Tour for teachers next summer seem bright. Replies to our October "feeler" were sufficient to justify tentative reservations for travel space and hotel accommodations. Planning of the itinerary and special visits is now under way. The group will be limited to 32 participants and the cost to each will be approximately $1400. Complete information and application forms will be available from NSTA headquarters about January 15, 1962.

For information on the first tour by NSTA, see the May 1961 copy of *TST*.



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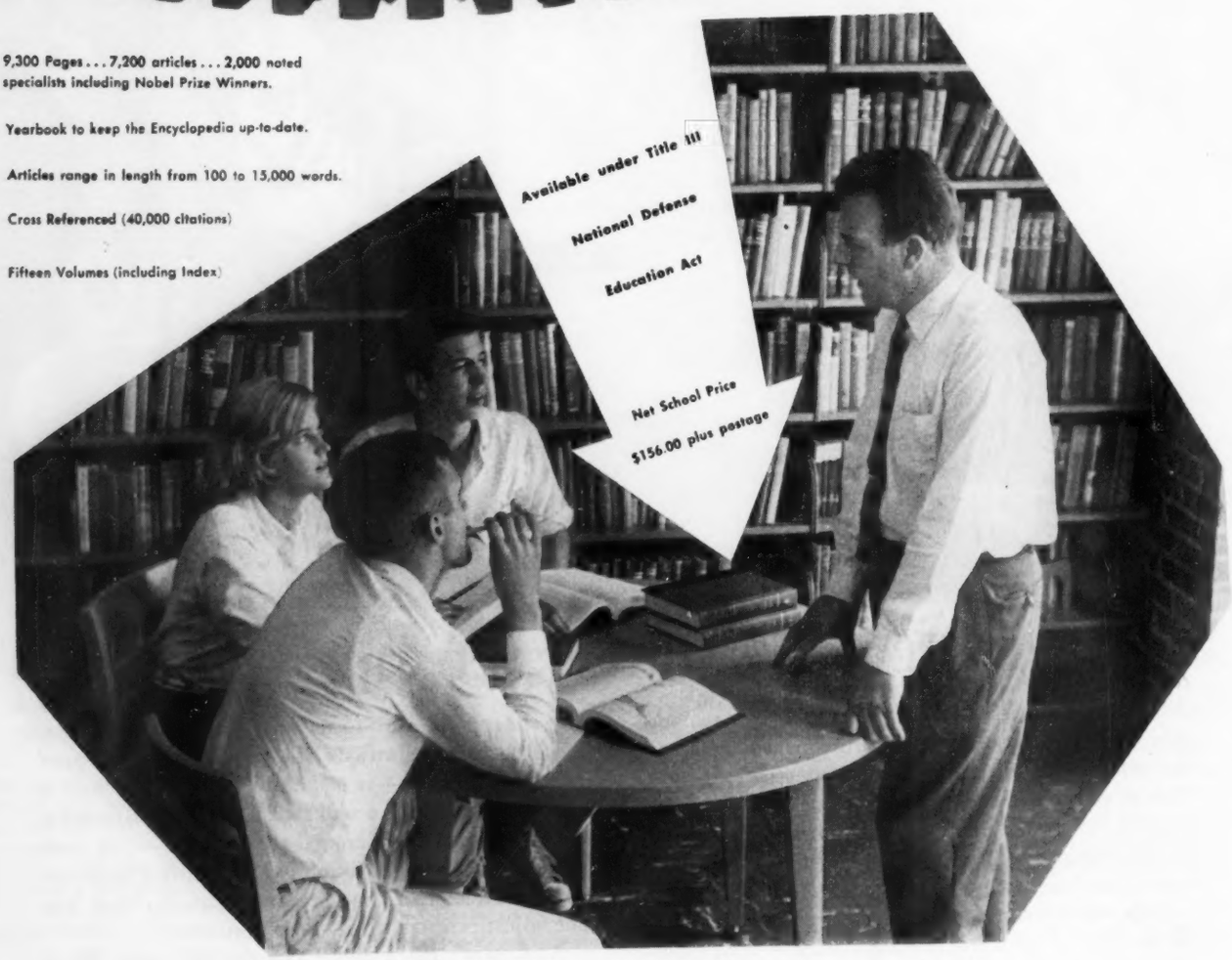

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BOOK Reviews

The Encyclopedia of the Biological Sciences. Peter Gray. 1120p. $20. Reinhold Publishing Corporation, 430 Park Ave., New York 22, N. Y. 1961.

As a comprehensive reference source, this volume is useful for anyone seeking information concerning specific areas of biology. Approximately 800 articles concerned with various areas of biology are included; many are excellently illustrated. The articles, arranged alphabetically, include new topics such as space biology and also bring up-to-date information about the more established areas of biology. The book is even more appealing because the articles are written by specialists in their respective fields. Persons such as Beadle, Alexopoulos, Romer, and Buchsbaum are contributors to this comprehensive treatment of biology.

In addition to the information provided by the contributor, a bibliography is provided also at the end of each article. Many of the articles are cross referenced. Autobiographies of famous biologists are provided in the volume. Students could obtain a historical perspective of biology from this information. Another interesting section of the volume provides a listing of the international biological societies and their addresses. An index is provided which will help students find information easily. Since the book is well bound, it should withstand considerable handling.

In attempting to review the volume as a possible high school reference, some objections are given. The text type is in small print. Moreover, there are some levels of difficulty in the use of technical terms. For example the use of such terms as *Alcyonidium hirsutum* may be difficult for most high school students to grasp. Another example is: "Trophallactic relationships are important in the cohesion of most colonies of social insects . . ." Students would need strong teacher guidance with various articles. Nevertheless, this volume can make a valuable contribution to high school biology programs and should be found in every high school science library.

BURTON E. VOSS
The Pennsylvania State University
University Park, Pennsylvania

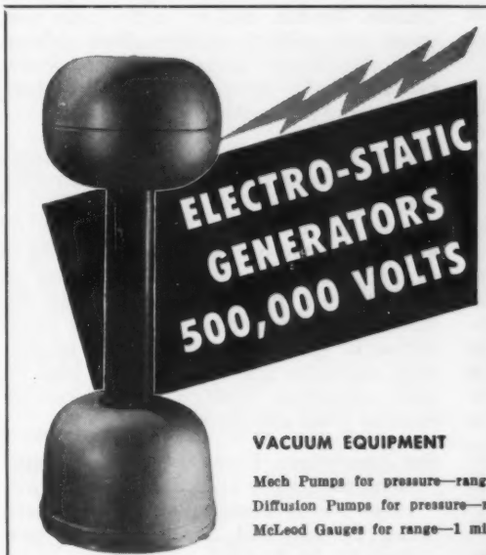
A Sourcebook for the Physical Sciences. Alexander Joseph, Paul F. Brandwein, Evelyn Morholt, Harvey Pollack, and Joseph F. Castka. 648p. $7.95. Harcourt, Brace and World, Inc., 750 Third Ave., New York 17, N. Y. 1961.

The authors in their preface indicate that their mission is to present a multitude of experiments, laboratory procedures, projects, and demonstrations which will, through the wise choices made by teachers, fit the variety of teaching situations in our schools. They have accomplished this goal. Current information, as for example, the descriptions of the Physical Science Study Committee materials and similar national programs for chemistry are included. When one contemplates the task of bringing together what the authors have accomplished, one might have some concern that the task is insurmountable. To make the wise choices from the innumerable activities available from which there are sources seems another insurmountable task. Here again, the authors have been wise in their choices of items for inclusion in the book.

The book is divided into three sections, the titles: Physical Science, Chemistry, and Physics. Each section is then sub-divided into general content topics for which activities are described. Generally, the authors not only describe the activity, but also give a reason or reasons for the observation recorded by the student. However, where appropriate, the student is led to complete the observation and formulate his own conclusion without help from the printed word. This is an appropriate technique. It would be difficult to state the proper grade placement for each; the activities and the authors have not fallen into this error. The reader will be pleasantly surprised to observe the wide range of difficulty involved in the activities. Some are well known, simple, and easily completed with a minimum of equipment. Others involve much more sophistication, both in equipment and in comprehension. The Introduction and the last two chapters of this book are worthy of special mention. The Introduction covers patterns in the use of laboratory techniques and procedures. In this, the authors generalize about teaching techniques and methodology. At the same time, enough specifics are included in the Introduction so the reader does not have the feeling that this "is the same old stuff." The titles of the last two chapters describe specifically the contents. These are: "Skills and Tools in the Laboratory," and "Science Facilities for a Science Program." In the latter two chapters, each author writes as the "old pro" who is giving his all to help the newcomer. Again, a dual role appears and we find new ideas interspersed with what we have always known as old tried-and-true ideas.

The appendix of this volume is especially useful. It includes reference tables; suggested readings; a bibliography of books for the science library; an excellent current list of films and filmstrips, including their producers; a directory of manufacturers, distributors, and supply houses. This book is highly recommended for the high school teacher of the physical sciences. It might be considered a *must* for the beginning high school teacher of the physical sciences.

H. SEYMOUR FOWLER
The Pennsylvania State University
University Park, Pennsylvania



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BOOK BRIEFS

Physics; The Pioneer Science. Lloyd W. Taylor. Volume I: Mechanics, Heat, Sound. Volume II: Light, Electricity. 848p. $4. Dover Publications, Inc., 180 Varnick St., New York 14, N. Y. 1960.

Volume I includes: Motion, Free Fall, Equilibrium, Vectors, Weight, Mass, Acceleration, The Infinitely Large, Gravitation, Atomism, Harmonic Motion, Conservation of Energy, Rotation, Temperature, Thermal Expansion, Heat and Mechanical Energy, Heat Engines, Sound, Acoustics of Rooms, Pitch, Intensity of Sound, Quality of Musical Tone, and other topics. Volume II includes: Properties of Light, Illumination, Images, Lenses, Prisms, Color, Length of Light Waves, Spectra, Polarized Light, Magnetism, Static and Current Electricity, Magnetic Effect of Current, Electrical Units, Ohm's Law, Electromagnetic Induction, Dynamos, Alternating Currents, Telegraph, Telephone, Quantum Theory, The Decline of the Mechanical View of Nature, and other topics. Problems are found at the end of each chapter. Publication is a complete paperbound textbook in two volumes.

Problem-Solving Methods in Science Teaching. Lester C. Mills and Peter Dean. 88p. $1.50. Bureau of Publications, Teachers College, Columbia University, New York 27, N. Y. 1960.

A monograph, one of a series, prepared by the Science Manpower Project. Chapter headings include: Introduction to Problem Solving, Problem Solving Opportunities, and Problem Solving in Earth Sciences—Biological Experience. Introduces the concept and meaning of problem solving. Discusses ways in which the teacher can recognize motivation. Gives a specific problem to be solved in the fields of biology, chemistry, and physics. Tells what evaluation should do and how it can be carried out. This book would be helpful to any teacher of science.

The Universe of Light. Sir William Bragg. 284p. $1.85. Dover Publications, Inc. 180 Varnick Ave., New York 14, N. Y. 1960.

This publication consists of an expansion of the Royal Institute Christmas Lectures by the author. This work includes the nature and working of lenses, reflection, refraction, the optics of vision and defects of the eyes, color, resonance, polarization, light and astronomy, X rays, crystal optics, cathode rays and other electron discharges, the photoelectric effect, lenses, and optical instruments. It also gives an explanation of the colors of a spectrum, rainbow, or soap bubble. Tells how magic mirrors and pinhole lenses work, and other simple demonstrations of basic laws and principles. The corpuscular and wave theories of light are also explained. Requires no scientific training for understanding and is written in an interesting style. An excellent addition to a science teacher's library.

Astronomy. H. C. King. 256p. $4.95. Franklin Watts Inc., 575 Lexington Ave., New York 22, N. Y. 1960.

One in the new series of Watts Illustrated Science Books. Chapter titles include: Before the Telescope, The Tools of Astronomy, The Sun, The Planets, The Stars, Our Galaxy—the Milky Way, and Beyond the Milky Way. Takes the reader from ancient myths and astrology through Copernicus, Galileo, Newton, and on to the radio telescope and artificial satellites. Well written; good illustrations; inclusive glossary. Interesting for the more mature high school student and his teacher.

The Wider Universe. Paul Couderc. 124p. $2.25. Harper and Brothers, 49 East 33rd St., New York 16, N. Y. 1960.

Author has given us a compact book of valuable proportions. By limiting himself to current knowledge of galactic activities he has set forth fundamental ideas that are valuable to the layman. The factual information of galactic movements, the spectral shift, and stellar activities make this book an easily understood addition to the reference material about our universe.

Our Atmosphere. Theo Loebsack. Translated from the German by E. L. and D. Rewald. 190p. 50¢. A Mentor Book. New American Library, 501 Madison Ave., New York 22, N. Y. 1960.

Book is written in layman's language with a style that makes entertaining reading. Begins with the various theories as to the formation of the atmosphere and subsequent beginnings of life. The various layers of the atmosphere are described and explanations of phenomena such as rainbows, mirages, and polar lights are given. Beginning with the process of photosynthesis, it explains how plants and animals make use of the air. Unusual examples of speed and lift of insects and birds are given. The composition of the atmospheres of the other planets of our solar system is given. Weather and weather-forecasting are presented with such topics as: the earth-wind system, the production of precipitation by cloud-seeding, tornadoes, hurricanes, the jet streams, thunder and lightning, and the Beaufort wind scale. The last portion of the book describes the oxygen and nitrogen cycles, the physiology of respiration, the principles of flight, theories as to whether our climate is changing, and the radiation dangers including physical and genetic injury.

Electricity: How It Works. Perry Dunsheath. 248p. $3.95. Thomas Y. Crowell Company, 432 Park Ave., New York 16, N. Y. 1960.

Covers topics which include: static electricity, magnetism, the electric current, the path of the current, electromagnetic effects, mechanical generation of electricity, alternating current and the transformer, as well as light and heat from electricity. Traces with clear and simple explanations the historical development of electricity. This is a book for high school students who are interested in the whole field of electricity. Contains many diagrams, charts, and detailed instructions for doing practical experiments in electricity.

Fun with Scientific Experiments. Mae and Ira Freeman. 60p. $1.50. Random House, Inc., 457 Madison Ave., New York 22, N. Y. 1960.

Covers 57 clearly illustrated physical science experiments which can be performed at home or in the classroom with students doing the actual experimenting. Experiments are safe and require a minimum of simple materials which can be obtained around the home or in the workshop. Highly recommended as an addition to the elementary school library or as a supplementary book in the classroom to stimulate scientific thought and interest. This is an up-to-date edition of a well-known publication.

Atomic Energy, The Story of Nuclear Science. Irene D. Jaworski and Alexander Joseph. 218p. $4.95. Harcourt, Brace and Company, 750 Third Ave., New York 17, N. Y. 1961.

The nature and structure of the atom, the relationship of its parts to each other, and how man learned to tap this vast supply of energy form the theme for this book. Recent facts on the atomic nucleus, fission, fusion, and isotope research are also included. There are a great many illustrations throughout the book, such as the use of "mechanical hands" to handle radioactive materials, the whole-body" scintillation counter, and the figure-eight fusion chamber. The book features many home experiments such as making a 110-volt AC Geiger counter, photographing the disintegration of a nucleus by

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a cosmic particle, and using the diffusion cloud chamber. Photographs and diagrams of most of the accelerators are also included.

The Anatomy of Plants. P. Font Quer. 128p. $2.25. Harper and Brothers, 49 East 33rd St., New York 16, N. Y. 1960.

One of the Science Today Series. Titles include: Cytology, Histology, Anatomy of Vegetative Organs, Internal Structure of Vegetative Organs, Modifications of the Plant Body, and Reproductive Organs. The cell and tissues are introduced in a brief and easy-to-understand manner. Internal and external anatomy of various parts of plants is discussed in the remainder of the book. Some drawings are used for illustration. The book is easy to read and understand, and it is brief and to the point. A fair reference book for high school biology students. An increase in the number and quality of the drawings would make it a much more useful book.

Hurricanes, Tornadoes and Blizzards. Kathryn Hittle. Illustrated by Jean Zallinger. 82p. $1.95. Random House, Inc., 475 Madison Ave., New York 22, N. Y. 1960.

The author has succeeded in producing an informative book written in a most entertaining style. The excellent illustrations are arranged to coincide with the adjacent reading material. The use of italicized print when technical terms are introduced is to be commended. Each type of phenomenon—hurricane, tornado, and blizzard is treated as to its origin, how (or probably how) it is formed, its destructive capabilities, and the pattern it may follow. The book would be a valuable addition to any elementary school library and could be profitably used in grades three through six.

Thunderstorms. Thelma Harrington Bell. 126p. $3. The Viking Press, 625 Madison Ave., New York 22, N. Y. 1960.

This book is written in layman's language in nontechnical terms. An excellent addition to the library in secondary schools. A vivid account is given of the development of a full-sized thunderstorm from a single cumulus cloud. Explains where the energy of the storm comes from, why the mass of air continues to rise, and the changes that take place as it rises. An explanation of the phenomenon of ionization with the formation of charge on clouds and the subsequent production of the lightning bolt are given. The three types of thunderstorms, air mass, frontal, and orographical are described.

How to Grow House Plants. Millicent E. Selsam. 96p. $2.75. William Morrow and Company, 425 Fourth Ave., New York 16, N. Y. 1960.

Good elementary data of a variety of indoor gardening projects including care of house plants, methods of propagation, and control of plant pests. There is a chapter on growth hormones also.

Man on the Moon: Our Future in Space. James Throneburg. 66p. $2.75. Alfred A. Knopf, 501 Madison Ave., New York, N. Y. 1961.

A book which answers many questions about the moon. Particular emphasis is given to the geography of the moon, the origin of the moon, and myths about the moon. An imaginary space trip to the moon is also described. Well illustrated. Suitable for upper elementary grades.

The Quest of Louis Pasteur. Patricia Lauber. Illustrated by Lee J. Ames. 56p. $2.50. Doubleday and Company, Inc., 575 Madison Ave., New York 22, N. Y. 1960.

In reading this book one is caught up in Pasteur's relentless search for truth. The reader's understanding of microbes grows as Pasteur's descriptions show how he developed his processes of thought. It gives a true grasp of the debt we all owe to the work of Louis Pasteur.

Rockets and Missiles. Bertha M. Parker. 36p. 35¢. Row, Peterson and Company, 1911 Ridge Ave., Evanston, Ill. 1961.

A Row, Peterson "Unitext" written for the junior high school level giving a thorough treatment of the scientific principles involved in rocketry. The different kinds of missiles and their uses are discussed. Well-illustrated diagrams help to clarify the written material. A worthwhile publication.

Look, Listen, and Learn. 24p. $2. per 100 copies. Coronet Films, Coronet Building, 65 East South Water St., Chicago 1, Ill. 1961.

Answers many questions concerning use of films. Lists items calling for alertness before, during, and after viewing films. Also covers special techniques such as slow motion, time-lapse photography, pictures taken through either microscopes or telescopes, and animation. Handy, condensed version of some audio-visual texts. Would be useful in preparing classes for viewing science films. If school science club has projectionist section, book would prove a useful aid.

Satellites and Space Travel. Bertha M. Parker. 36p. 35¢. Row, Peterson and Company, 1911 Ridge Ave., Evanston, Ill. 1961.

A Row, Peterson "Unitext" written for the junior high school level. An excellent source of information. Topics discussed are space, satellites, escape velocity, barriers to space travel, Project Mercury, spaceship of the future, space stations, and space flight to the moon. Well illustrated and highly recommended.

The Mound Builders. William E. Scheele. 62p. $2.50. The World Publishing Company, 2231 West 110th St., Cleveland 2, Ohio. 1960.

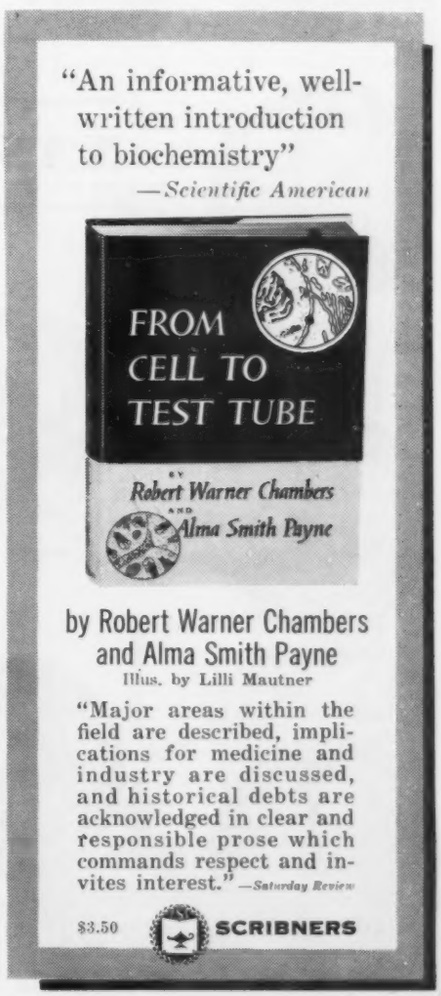
The story of the Hopewell Indians as revealed by their mounds located in the Ohio River valley. These prehistoric mounds contain a wealth of information about the early inhabitants of this region. Contains many pages of illustrations and diagrams. Good for earth science or social studies on the elementary and early junior high level.

Science Puzzler. Martin Gardner. 128p. $2. The Viking Press, 625 Madison Ave., New York 22, N. Y. 1960.

Contains over 100 experiments which can be done with materials found in the home. An excellent source of party stunts. The experiments, in addition to being entertaining, also teach something of importance about science. Some of the experiments would be useful in stimulating interest in the classroom about the scientific principle on which they are based. Experiments cover areas of astronomy, chemistry, physiology, psychology, general mathematics, topology, probability, geometry, numbers, light, gravity, static electricity, mechanics, air, hydraulics, heat, sound, and inertia.

Integrated Principles of Zoology. Second Edition. Cleveland P. Hickman. 972p. $7.75. The C. V. Mosby Company, 3207 Washington Blvd., St. Louis 3, Mo. 1961.

A complete zoology textbook which is divided into six parts. Part I concerns the functional organization of animals. Part II treats the various phyla of the animal kingdom progressing from the simple to the complex. Part III treats the organ systems in related groups. Vertebrate and invertebrate structures are covered. Part IV, the Origin and Relationship of Animals, covers the continuity of life as is revealed by the study of development, heredity, and evolution. Part V presents the adaptive and environmental relations of organisms. This includes biotic factors, ecological succession, food cycles, the distribution of animals, unusual and interesting adaptations, and behavior patterns. Part VI lists chronologically the basic concepts, key discoveries, and books that influenced the development of zoology from the time of Aristotle to the present.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SCRIBNERS

PROFESSIONAL READING

"The Problem of Sciences and the Humanities." By Harold G. Cassidy. *Journal of Chemical Education,* 38:441. September 1961. A prescription for improving communications between and among scientists and humanists is given in this national Sigma Xi lecture. Two new diagrams attempt to find the relationship among the arts and sciences. Differences and similarities in communications and functions are presented in a lucid analysis of the two cultures which must intermesh for responsible opinions and actions to be spawned.

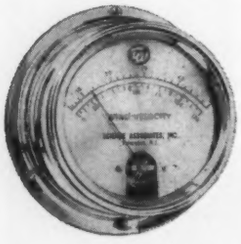
"Preschool Physics." By Frieda A. Stahl. *American Journal of Physics,* 29:579. September 1961. ". . . to lead the children into a cooperative investigation of various aspects of their environment, in which simple demonstration experiments would be performed with the children themselves participating." This was the objective that author Stahl set for herself when she set out to develop physical science activities for nursery school. At the time the article was written lessons had been developed in light, sound, electricity, magnetism, and the states of matter. The article explains the pitfalls and the success that this program met during its development.

"The Living Cell." *Scientific American,* 205:250. September 1961. A series of ten articles explore the functions and features of the cell. The materials in this issue were prepared by fourteen scientists—authors from throughout the world who have combined their talents and experience to present the most recent information on the fundamental unit of organisms. This entire issue will be a valuable resource for high school biology teachers. Students and teachers with special interests will find stimulation, ongoing new ideas and information, and a wealth of illustrative materials.

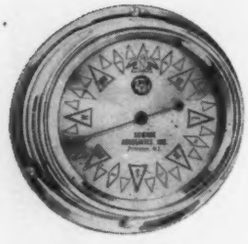
"A New Look at Math." *The Lamp,* Standard Oil Company of New Jersey, 30 Rockefeller Plaza, New York 20, N. Y. 43:16. Summer 1961. "Not only physics but every science depends on the language of mathematics." This statement by Jane Werner Watson in her book, *The World of Science,* characterizes a project under way since 1958 at The John Hopkins University, Baltimore, Maryland. This article explains how the University developed an in-service institute for teachers to bring about ". . . 'marrying' math and the physical sciences . . ." The reactions of some of the persons who attended the institute are given as well as some of the results being achieved at the classroom level.

"Modern Junior High School Science: A Recommended Sequence of Courses." By Abraham S. Fischler. 128p. 1961. This monograph develops a sequence of science courses for our junior high schools and the reasons behind the selections. One of the unique features of the entire program is that it is based upon an awareness that elementary school science has been making rapid strides, and has influenced the teaching in our 7-9 programs. Another factor that was taken into account in the study is that many school systems are based on an 8-4 system rather than a 6-3-3 basis. The program presented in this publication can be adopted to either school make-up. In addition to content and organization for grades 7-9, the book covers topics such as facilities and equipment, plus evaluation and guidance. $2. Bureau of Publications, Teachers College, Columbia University, New York City.

"How to Attract More Girls to High School Physics." By Katherine Way, Mary E. Warge, and Mary Louise Robbins. *Physics Today,* 14:30. September 1961. A stiffer set of standards in science than in other subjects, the engineering aspects of physics, the shock of poor marks, and not enough adequately trained physics teachers are among the factors which keep girls out of high school physics. Introducing science at a grade level earlier than is now common would assist in attracting more girls to physics. Also, physicists and other scientists can positively influence the community's thinking about science through public speaking.



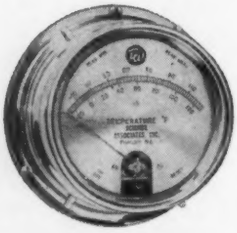
Wind Speed



Wind Direction

Relative Humidity

Barometric Pressure



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Light for Beginners. This excellent film will introduce very young children to some of the basic properties of light. Illustrates simply, the differences between sunlight and artificial light. Explains how light produces shadows and how it travels in a straight line, for all practical purposes, and how light can be reflected and refracted. A young girl, her family, and their pets serve as characters in a story which dramatizes important concepts of light. The topic is well organized and leads the viewer into a review without formality. Recommended for kindergarten through grade 3. 11 min. Color $110, B&W $60. 1960. Coronet Instructional Films, Coronet Building, 65 East South Water St., Chicago 1, Ill.

A Community Keeps Healthy. Film emphasizes the tremendous task that faces a community in keeping its people healthy. Covers such subjects as milk, fruit, vegetables, canned and packaged foods, water supply, and pure air. Points out the governmental agencies attempting to watch over and to keep people healthy. Stresses the fact that provisions for maintaining good health are the responsibility of all citizens and cannot be accomplished by agencies alone. Recommended for science and health classes in early elementary grades. 11 min. Color $110, B&W $60. 1961. Film Associates of California, 11014 Santa Monica Blvd., Los Angeles 25, Calif.

The Clothes We Wear. Film discusses the various fibers that are used in clothing. Illustrates the manufacturing of clothing from wool, cotton, silk and flax and explains their warmth-giving properties. Develops an appreciation for the abundance as well as the value of the clothes we wear. Recommended for elementary science, grades 2-6. 11 min. Color $110, B&W $60. 1960. Churchill-Wexler Film Productions, 801 North Seward St., Los Angeles 38, Calif.

Prove It with a Magnifying Glass. Shows a small boy exploring various objects in his environment with a magnifying glass. Observations are made of cloth, a grasshopper, a feather, a rock, the bark of a tree, a moth, a newspaper picture, a soap bubble, and the ridges on the skin of the fingers. The film points out that when things are magnified they look different and are easier to study. The lens of the magnifying glass is compared to lenses found in microscopes and telescopes. For primary and middle elementary grades. 11 min. Color $110, B&W $60. 1961. Film Associates of California, 11014 Santa Monica Blvd., Los Angeles 25, Calif.

Foothold on Antarctica. This British-made film is a record of the journey preliminary to the Trans-Antarctic Expedition led by Sir Vivian Fuchs and Sir Edmund Hillary. The advanced party starts out to establish a base, Shackleton, at the Weddell Sea. The thrilling journey was made in the Canadian sealing vessel, *Theron*, across the ice pack. For junior or senior high school. 20 min. Color $150. 1960. Contemporary Films, Inc., 267 West 25th St., New York 1, N. Y.

Electricity, Principles of Safety. Begins with a discussion of safety features by illustrating the various ways a circuit can be broken through faulty wiring and by open switches. The film uses the everyday examples of a young boy's experiences as he looks at appliances which are energized by an electric current. Proceeds to describe the correct and incorrect method of using various examples of electrical apparatus and circuitry. Recommended for intermediate grade science classes. 11 min. B&W $60. 1961. Coronet Films, Coronet Building, 65 East South Water St., Chicago 1, Ill.

We Use Power. The various forms of power covered are: wind, water, steam, and electricity. The power of burning gases in gasoline, diesel, and jet engines is illustrated to show how they are controlled to help man. The students explore the various forms of power through simple experiments such as making an electromagnet, a simple steam turbine, and a simple motor. Recommended for grades 3-7. 11 min. Color $110, B&W $60. 1960. Churchill-Wexler Film Productions, 801 North Seward St., Los Angeles 38, Calif.

APPARATUS & EQUIPMENT

The Graf-Apsco Microscope Model GB2A. This microscope, acceptable for purchase under the NDEA program has all the features of a well-engineered, durable, all metal instrument, desirable for use in high school laboratory work. It incorporates effective focusing adjustments that are smoothly operated and provide excellent resolution. The stand is well balanced, full standard size. The base extends beyond the stage and objective which protects stage and objective lenses. The coarse and fine adjustment are rack and pinion and are located on both sides of the arm. A focusing safety stop is incorporated on coarse adjustment but this does not eliminate danger of slide breakage on high power. The tube is vertical. The nosepiece is of a double revolving dustproof type that locks in place. Nosepiece is equipped with 10X (0.27NA) and 44X (0.66NA) achromatically correct objectives, mounted permanently, parfocal and centered. The eyepiece is a removable 10X Huygenian type. The stage is standard size and equipped with slide clips. An aperture disc diaphragm with five openings is provided. A single concave adjustable mirror or attached illuminator is provided at the same price. This microscope is priced competitively with others in its class. $117 each; $105.03 (5 or more). The Graf-Apsco Company, 5868 Broadway, Chicago 40, Ill.

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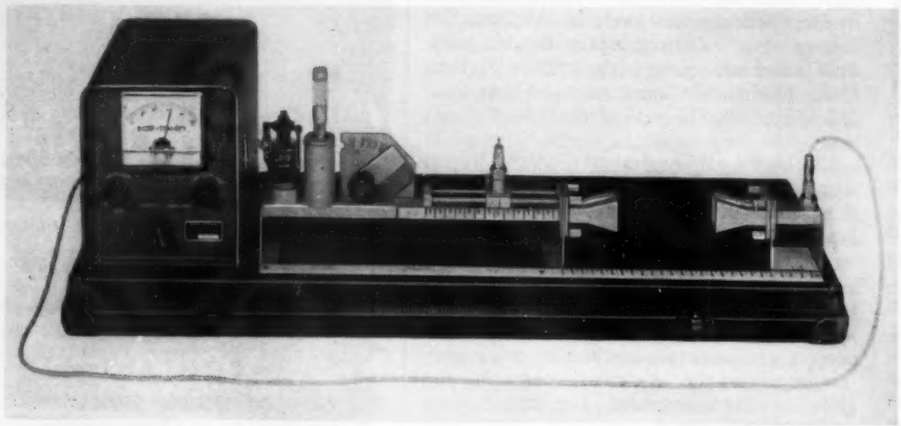

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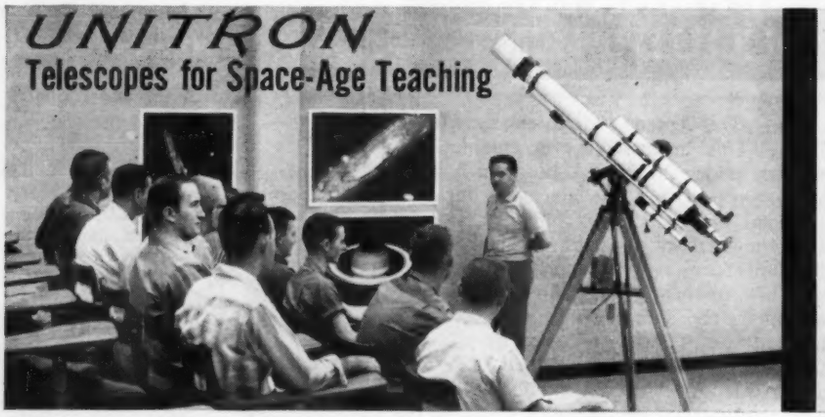

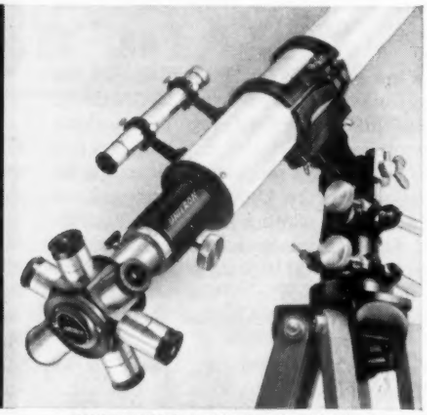

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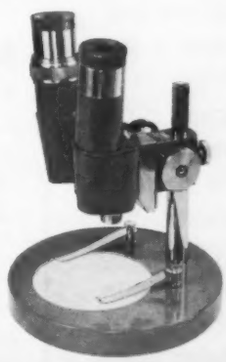

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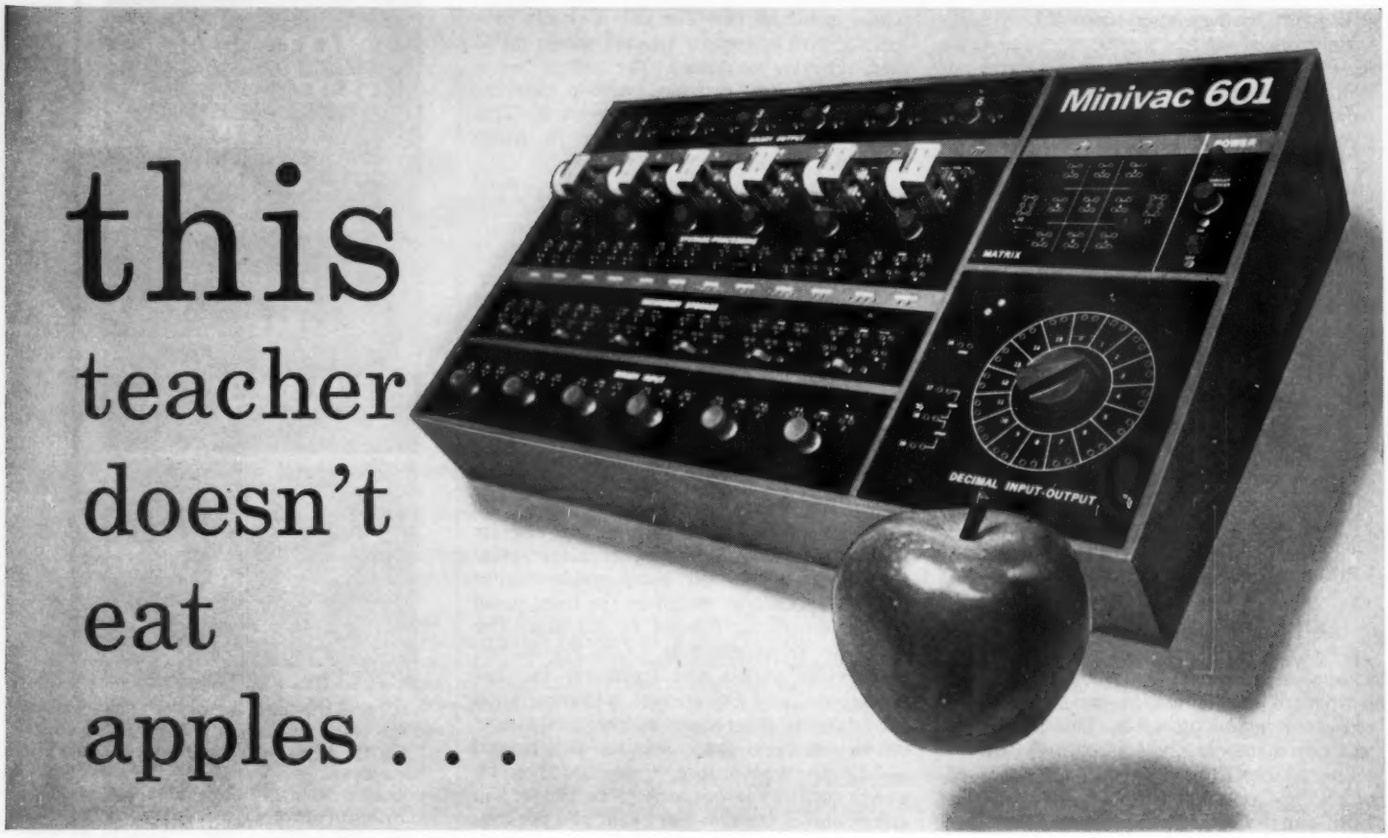

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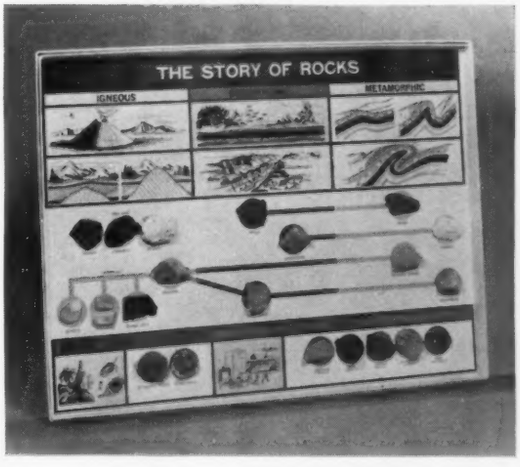

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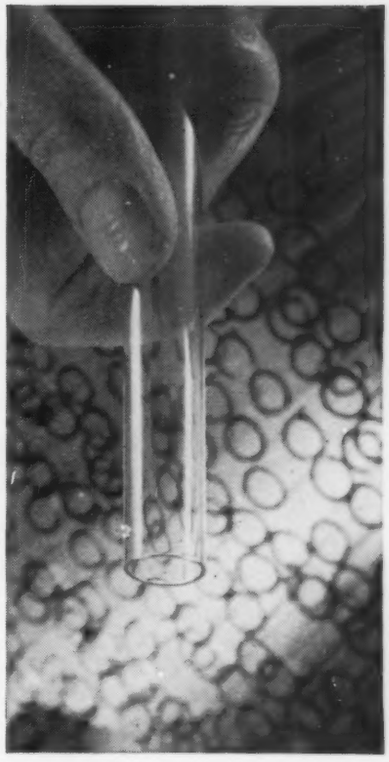

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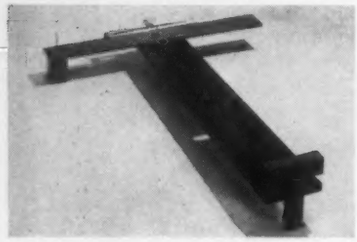

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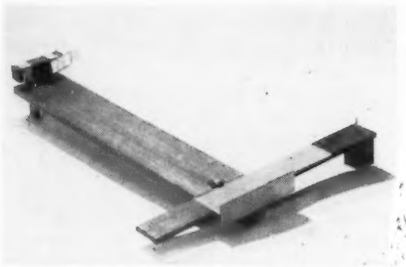
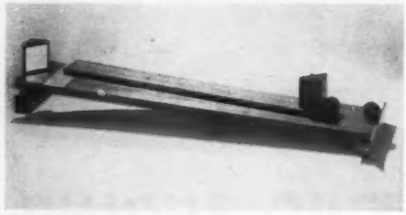


Model 4200 — Optical Micrometer



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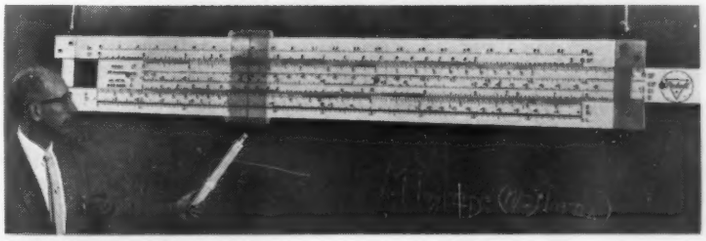

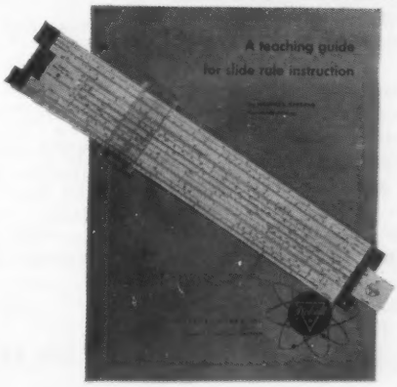

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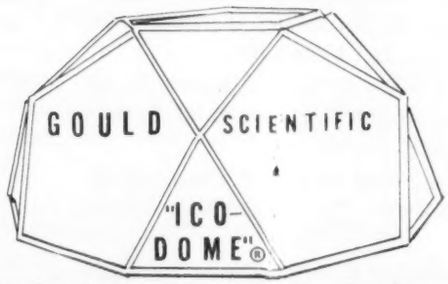

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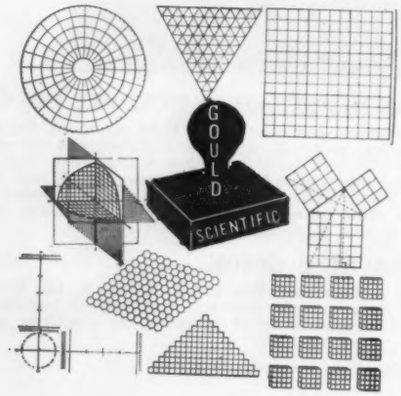

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Distance Measurement by Wave Interference in a Ripple Tank. Martin Annis, John Walters, and Edwin C. Williams, Jr. October: 26. **(7)**

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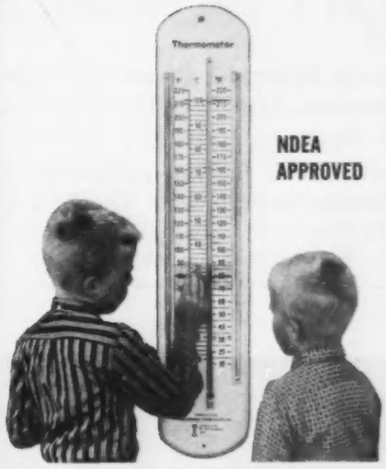

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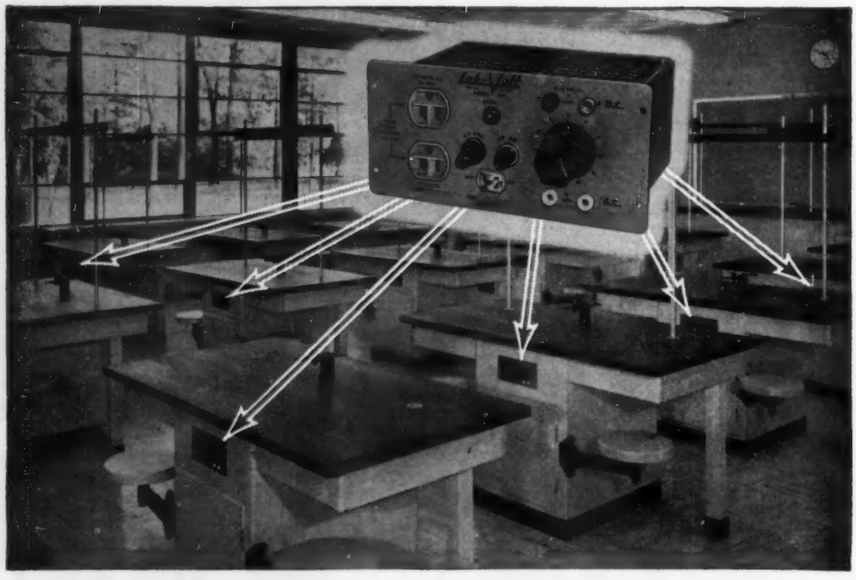

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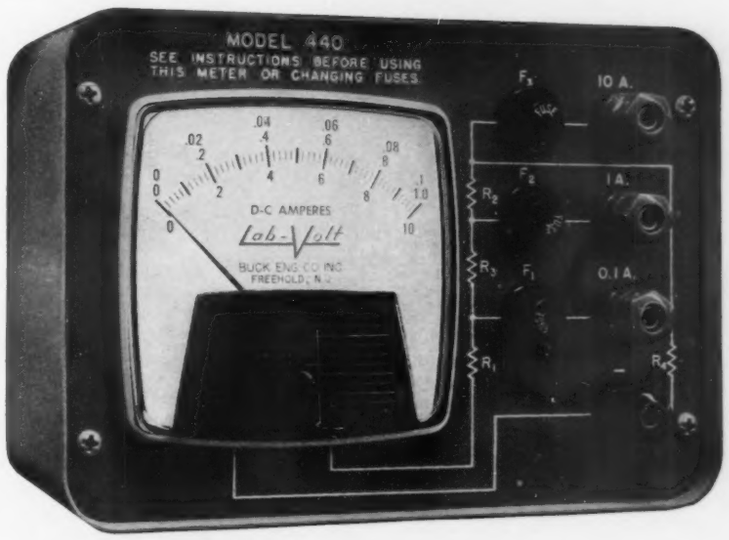

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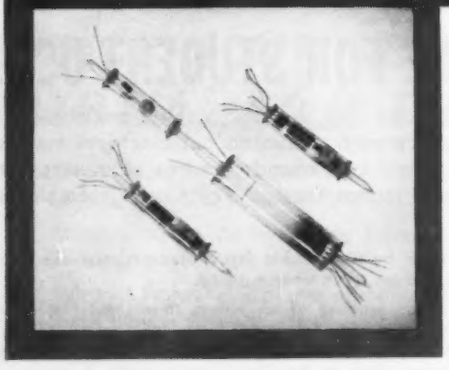

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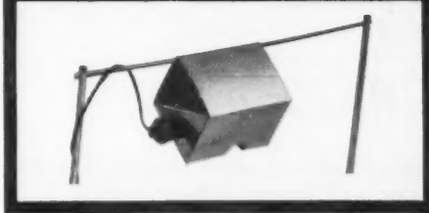

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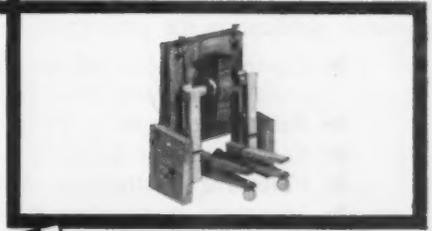

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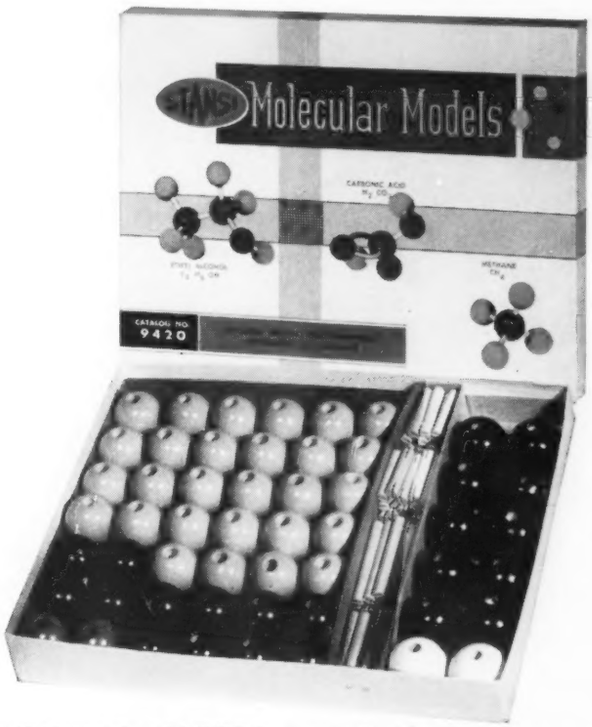

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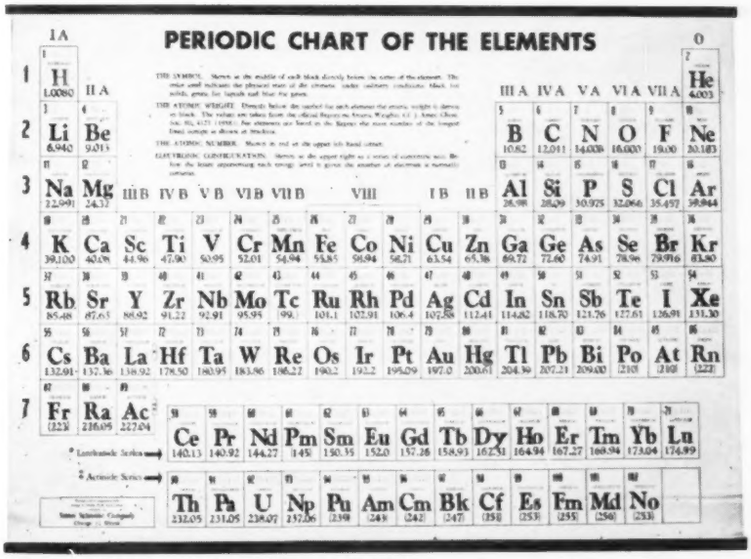
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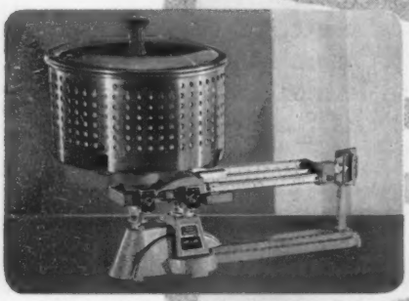

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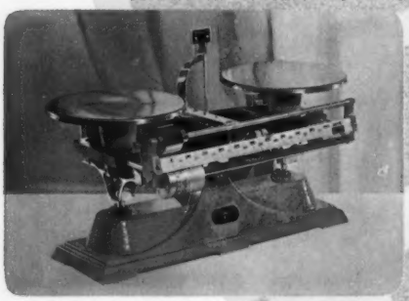

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